ALBERTA TIER 1 SOIL AND GROUNDWATER REMEDIATION GUIDELINES

Alberta
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REMEDIATION GUIDELINES

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1. INTRODUCTION

1.1 Alberta's Framework for the Management of Contaminated Sites

Alberta's framework for the management of contaminated sites is designed to achieve three policy outcomes:

- **Pollution prevention**: Avoid "impairment of, or damage to, the environment, human health or safety, or property".
- **Health protection**: Take action on contaminated sites that is commensurate with risk to human health and the environment.
- **Productive use**: Encourage remediation and return of contaminated sites to productive use.

Under this framework, three management options are provided: Tier 1, Tier 2, and Exposure Control. Within a given land use, sites will fall into a range of sensitivities because of differences in receptors and site conditions. Tier 1 remediation guidelines are generic; that is, they are developed to protect sites at the more sensitive end of the range and can therefore be used at most sites without modification. The Tier 2 approach allows the consideration of site-specific conditions through the modification of Tier 1 guidelines and/or removing exposure pathways that may not be applicable to the site. Exposure Control involves risk management through exposure barriers or administrative controls based on site-specific risk assessment. These management options are described in more detail in Section 3.

The Tier 1 approach is based on the assumption that all exposure pathways and receptors relevant to a particular land use are actually present. At Tier 1, exposure pathways that are part of the generic scenario for the applicable land use may not be screened out. Under Tier 2 it may be possible to screen out certain exposure pathways and/or modify the Tier 1 guidelines on the basis of site conditions. These options are discussed further in Sections 3 and 5, and in *Alberta Tier 2 Soil and Groundwater Remediation Guidelines* (AENV, 2008a).

1.2 Tier 1 and Tier 2 Levels of Protection

The objective of the Tier 1 and Tier 2 soil and groundwater remediation guidelines is to deliver the same degree of human health and ecological protection, regardless of which option is used. The same protocols are used to develop both Tier 1 and Tier 2 guidelines. The two options differ in the amount of site-specific information used to develop the guidelines.

The Tier 1 remediation guidelines are simple tabular values that require minimal site information for their use. Conservative assumptions about soil and groundwater characteristics have been used to develop the Tier 1 guidelines to protect sites likely to be sensitive to contamination. In this way, less sensitive sites under the applicable land use are also protected. Some site information is needed to ensure that site conditions are

adequately represented by the assumptions used to develop the Tier 1 guidelines. Those sites that may be more sensitive than conditions assumed in the Tier 1 guidelines are more appropriately dealt with under the Tier 2 approach.

Applying Tier 2 guidelines typically requires more information from the site than Tier 1 guidelines. This additional information allows the assessor to develop guidelines that are tailored to the particular characteristics of the site. When a site has characteristics that make it more sensitive than the Tier 1 assumptions, the resulting Tier 2 guidelines may be more restrictive than Tier 1 values. Sites which are less sensitive may have Tier 2 guidelines that are less restrictive than Tier 1 values, but which deliver the same level of human and ecological health protection because they are tailored to that specific site.

When adverse effects are evident, contaminants must be managed to alleviate adverse effects, regardless of whether a site meets Tier 1 or 2 remediation guidelines.

1.3 Relationship to Other Guideline Documents

This document focuses on Tier 1 soil and groundwater remediation guidelines, the process used to develop them, and the manner in which they should be applied. The *Alberta Tier 2 Soil and Groundwater Remediation Guidelines* (AENV, 2008a) expands on the Alberta Environment three-tiered system of contaminated site management (summarized in Section 3 of this document) and, in particular, provides the detail needed to make Tier 2 adjustments to the Tier 1 guidelines.

The soil and groundwater guidelines in this document supersede the following guideline documents:

- *Alberta Tier I Criteria for Contaminated Soil Assessment and Remediation* (AEP, 1994)
- *Alberta Soil and Water Quality Guidelines for Hydrocarbons at Upstream Oil and Gas Sites* (AENV, 2001a); and
- *Risk Management Guidelines for Petroleum Storage Tank Sites* (AENV, 2001b).

The following documents contain additional information needed for the application of Tier 1 guidelines and should be used in conjunction with this document:

- *Guidelines for the Remediation and Disposal of Sulphur Contaminated Solid Wastes* (AEP, 1996);
- *Surface Water Quality Guidelines for Use in Alberta.* (AENV, 1999);
- *Salt Contamination Assessment and Remediation Guidelines* (AENV, 2001c);
- *Soil Quality Guidelines for Barite: Environmental Health and Human Health* (AENV, 2004);
- *Assessing Drilling Waste Disposal Areas: Compliance Options for Reclamation Certification* (AENV, 2007)

- *Canadian Environmental Quality Guidelines* (CCME, 1999 and updates);
- *Reference Method for the Canada-Wide Standard for Petroleum Hydrocarbons in Soil - Tier 1 Method* (CCME, 2001); and
- *Canadian Guidelines for the Management of Naturally Occurring Radioactive Materials (NORM)* (Health Canada, 2000).

Two documents provide the protocols and the primary technical basis for the risk-based guidelines calculated in this volume:

- For all compounds except petroleum hydrocarbons: *A Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines* (CCME, 2006); and,
- For petroleum hydrocarbons: *Canada-Wide Standards for Petroleum Hydrocarbons (PHCs) in Soil* (CCME, 2008).

1.4 Ongoing Commitment

The *Alberta Tier 1 Soil and Groundwater Remediation Guidelines* is a living document. Alberta Environment is committed to updating the guidelines as new information and guidelines for new substances become available.

2. ALBERTA ENVIRONMENT POLICY ON CONTAMINATED SITE MANAGEMENT

This section provides an introduction to the guiding principles that underlie Alberta Environment policy on the management of contaminated soil and groundwater. These principles and the associated policy provide a framework for implementing the three contaminated site management options: Tier 1, Tier 2, and Exposure Control.

2.1 Pollution Prevention

Pollution prevention is a critical factor in maintaining a healthy environment. Alberta Environment policy strongly emphasizes the importance of proactive efforts that keep soil and groundwater clean and free of contaminants rather than relying on remediation after contamination has occurred. Remediation programs are often costly and, in the case of large and complex contaminant releases, may not be capable of fully restoring the quality of contaminated land or water, leading to a loss of land or water use options. Soil and groundwater contamination may be prevented or minimized by exercising care and control through:

- proper siting of facilities and chemical storage areas;
- secondary containment of potential contaminants;
- regular inspections and maintenance of tanks and pipelines;
- soil and groundwater monitoring programs;
- early source identification and removal or management; and,
- proper waste disposal and management.

2.2 Legislation

Two key acts, the *Environmental Protection and Enhancement Act* (Government of Alberta, 2006), and the *Water Act* (Government of Alberta, 2000) form the legislative basis of Alberta Environment's policies on the management of contaminated soil and groundwater.

2.2.1 *Environmental Protection and Enhancement Act*

Regulatory requirements related to substance release, remediation and reclamation are found in the *Environmental Protection and Enhancement Act* (EPEA). The purpose of the EPEA (Government of Alberta, 2006) is "to support and promote the protection, enhancement and wise use of the environment". The EPEA allows the Minister to establish guidelines and objectives.

Substance Release Provisions

The EPEA prohibits the release of substances in an amount that causes or may cause a significant adverse effect. "Release", "substance", and "adverse effect" are defined in

the EPEA. The release of a substance to the environment can occur rapidly (as in the rupture of a vessel containing the substance) or over a longer period of time (as with a gradual leak from an underground pipe that goes undetected). When a substance is released that causes an adverse effect or, for releases after Sept. 1, 1993, has the potential to cause an adverse effect, the release must be reported. Remedial measures must be implemented whenever a release causes, or has the potential to cause, an adverse effect. Additional guidance on release reporting can be found in *A Guide to Release Reporting* (AENV, 2005) and *Informational Letter 98-1* (ERCB, 1998).

Remediation Certificates

The EPEA authorizes the Director or inspector to issue remediation certificates where contaminated land has been remediated. While encouraging remediation of contaminated land, the remediation certificate also protects the responsible party from future environmental protection orders related to the remediated release.

Conservation and Reclamation

The EPEA includes requirements for the conservation and reclamation of specified land. Specified land is defined in the EPEA and the *Conservation and Reclamation Regulation* (Government of Alberta, 1993; C&R Reg.). The EPEA and the C&R Reg. require reclamation of specified land to equivalent land capability. Equivalent land capability is defined in the C&R Reg. With respect to soil contamination on specified land, the *Alberta Tier 1 Soil and Groundwater Remediation Guidelines* establish generic remediation guidelines for achieving equivalent land capability. Site-specific guidelines for achieving equivalent land capability can be developed using a Tier 2 approach.

2.2.2 *Water Act*

Water is a public resource, and is owned and regulated by the Government of Alberta. Regulatory requirements related to the management of water supplies and water quality (including groundwater quality) are found in the *Water Act* (Government of Alberta, 2000). The purpose of the *Water Act* is "to support and promote the conservation and management of water, including the wise allocation and use of water". The *Water Act* allows the Minister to establish guidelines for water management.

2.3 Principles of Contaminant Management

A contaminant is a substance that is present in an environmental medium in excess of natural background concentration (CCME, 2006). Three key elements of Alberta's framework for the management of contaminated sites are: source control, contamination delineation, and contaminant management, including remediation.

2.3.1 Source Control

A source of contamination is anything that adds contaminant mass to the environment. Source control is a necessary action in support of pollution prevention, a key outcome of Alberta's policy on contaminated site management. If there is evidence of soil or

groundwater contamination, the source, if it is still present, must be identified. Sources must be removed or controlled as soon as practicable.

Contaminants can be introduced into the environment in a number of ways. Leaking pipelines and storage tanks are common sources of contamination. Contaminated soil and groundwater may be a source of contamination to other areas of a site if the contaminants are mobile. Removal or management of these sources is a necessary part of contaminated site management. Soil or groundwater with naturally elevated substance concentrations may become a source of contamination if it is redistributed and causes the receiving soil or water to exceed Tier 1 or 2 remediation guidelines. This can be avoided by proper characterization and handling of soil and groundwater prior to redistribution. Failure to control sources allows contaminants to spread, increasing risk and remediation costs, and potentially limiting future land use if remediation to Tier 1 or 2 guidelines is not possible.

Where complete source removal is not feasible, the source must be removed to the extent possible and treatment, control, and/or management measures must be implemented to address the residual source. Treatment measures will assist in the ongoing reduction of source contaminant concentrations. Source control measures must prevent the contaminant from spreading to adjacent areas, causing the soil or groundwater there to exceed Tier 1 or 2 guidelines.

If source control measures are required, they must operate until the source meets Tier 1 or Tier 2 remediation guidelines. Source control must be supported by a monitoring program that demonstrates its efficacy.

Where source control rather than source remediation is implemented, a site is considered to be managed through an Exposure Control approach rather than a Tier 1 or Tier 2 approach.

2.3.2 Delineation

When soil or groundwater is found to contain contaminants in excess of Tier 1 or 2 soil or groundwater remediation guidelines, a delineation program must be implemented (Fig. 3). The delineation program must identify both the horizontal and vertical extent of contaminant concentrations exceeding the Tier 1 guidelines or the Tier 2 guidelines derived by the pathway exclusion approach (Section 5.2 and Table 5 in AENV, 2008a). Adequate delineation provides information needed to support appropriate decisions about contaminant remediation and management. Delineation programs must be extensive enough in both horizontal and vertical directions to allow all applicable exposure pathways and receptors to be properly assessed. Delineation is complete when measured concentrations are less than Tier 1 or 2 remediation guidelines. Complete delineation must be accomplished prior to undertaking remediation. The only exception is for relatively simple sites where contaminants are removed by excavation and compliance with Tier 1 guidelines is shown by post-excavation sampling. When confirmatory samples fail to comply with Tier 1 guidelines after excavation is complete, full

delineation of the remaining contamination must be undertaken and used to develop further remediation actions or risk management programs.

2.3.3 Contaminant Management

When the volume of soil or groundwater containing contaminant concentrations that exceed Tier 1 or 2 guidelines is completely delineated, a plan must be developed to remediate or otherwise manage the contaminants in a manner that is consistent with the framework outlined in Section 3. Using dilution to reduce contaminant concentrations is not an acceptable form of management, unless authorized by the appropriate regulatory authority under an operating approval, code of practice, or directive.

2.3.4 Management of Contaminants in Subsoil

In general, Alberta Tier 1 surface soil remediation guidelines apply to all soil and groundwater, regardless of depth. However, subsoil guidelines for salinity and petroleum hydrocarbons may be used at Tier 1 under the following circumstances:

Salinity

Topsoil guidelines for electrical conductivity and sodium adsorption ratio must be applied to the L, F, H, O, and A horizons (Soil Classification Working Group, 1998) or equivalent surficial material where these horizons are not present. Subsoil guidelines may be applied below the A horizon or equivalent in lieu of topsoil guidelines. Further information is available in the *Salt Contamination Assessment and Remediation Guidelines* (AENV, 2001c).

Petroleum Hydrocarbons

Surface soil guidelines for petroleum hydrocarbon fractions F1 to F4, benzene, toluene, ethylbenzene, and xylenes must be applied to a depth of 1.5 metres. Subsurface guidelines may be used as follows:

- Below 1.5 metres in depth within a 5 metre setback from an oilfield wellhead (see Municipal Affairs and Housing Advisory Land Use Planning Notes on Abandoned Wellsites), or
- below 3 metres in depth at any site.

The Tier 1 approach allows the exclusion of the ecological direct contact pathway for soil and groundwater for petroleum hydrocarbon fractions F1 to F4 for any land use below a depth of 3 metres. All other exposure pathways apply. Consistent with the *Canada-Wide Standard for Petroleum Hydrocarbons in Soil* (CCME, 2008), exclusion of the ecological direct soil contact pathway is permitted below 3 metres with the application of "management limits" for petroleum hydrocarbon fractions that represent maximum concentrations that apply at any depth. Management limits for petroleum hydrocarbon fractions F1 to F4 are noted in Appendix A.

2.4 Soil Protection in Alberta

Soil is a resource that supports important ecosystem functions. As a society, we rely on our soil resources to supply food and fibre, purify water, degrade waste materials, maintain healthy forests and grasslands, and provide a structural foundation for urban and rural buildings and infrastructure. As stewards of our soil resource, we have a responsibility to manage our activities in a way that sustains the ecological functions of soil. At sufficient concentrations, soil contamination can impair the ability of soil to support important ecosystem functions as well as pose risks to human health. Care must be taken to prevent soil contamination and, when a substance release occurs, prompt actions must be taken to remediate or otherwise manage the release. Maintenance of good soil quality will ensure that soil fulfills its ecological role and will maintain our land use options as Alberta continues to grow and diversify.

2.4.1 Using Tier 1 Soil Remediation Guidelines

The goal of the Tier 1 soil remediation guidelines is to provide numerical targets for remediation of contaminated soil. To ensure consistency with "pollution prevention", a key outcome of Alberta's contaminated sites management framework, the Tier 1 soil remediation guidelines are **not** "pollute-up-to" levels. Sources must not be left uncontrolled until cumulative releases result in an exceedance of Tier 1 or Tier 2 soil remediation guidelines. This results only in further contamination, increased remediation costs, and potential loss of land use options. Source control is a crucial component of pollution prevention.

2.4.2 Background Soil Quality

The background concentration of a substance in soil is the natural concentration of that substance in the absence of any input from anthropogenic activities or sources. In some situations, the background concentration of some substances can be a significant proportion of, or even exceed, the Tier 1 guidelines. In cases were the natural background is demonstrated to be greater than Tier 1 guidelines, the remediation level shall be to natural background or to guidelines developed using Tier 2 procedures.

Background concentrations will vary with soil parent material, soil depth, and hydrologic regime. These factors lead to spatial variations in background concentrations that may or may not be predictable. To gain a good understanding of background conditions at a site, it is necessary to take sufficient representative samples from soils with similar characteristics to the affected site, but which are taken from outside the area affected by contamination. Sample depth and landscape position, soil profile characteristics and parent material should be recorded for all samples.

Care should be taken to distinguish between apparent background concentrations that are the result of diffuse anthropogenic sources, and true, natural background conditions. In comparing against background, emphasis should always be placed on ensuring that anthropogenic sources are not identified as natural background.

2.4.3 Land Use

Potential receptors and their exposure to soil contaminants are affected by land use. For example, workers on an industrial site experience a different exposure than a toddler living on a residential property. Different ecological receptors are found in a forest setting than on an urban commercial property. Tier 1 soil remediation guidelines are calculated for five types of land use: natural areas, agricultural, residential/parkland, commercial, and industrial. These land use types may not correspond exactly to the range of municipal zoning options, but by evaluating the types of receptors and exposure conditions used in calculating the guidelines for each land use scenario, it is possible to identify which land use scenario is protective for a particular municipal zoning requirement. Assessors must determine the full range of uses allowed under the applicable zoning bylaw when determining the appropriate land use for Tier 1 application. Where a municipal zoning decision incorporates more than one land use scenario, the most conservative land use must be applied. More detailed guidance on land use may be found in Section 3.2.

In some cases, a contaminated site may be adjacent to a property with a more sensitive land use. Even though contaminant concentrations may meet appropriate guidelines for the less sensitive land use, mobile substances may migrate to the adjacent property at concentrations that exceed guidelines for the more sensitive land use. This is a particular risk for the vapour inhalation pathway and the groundwater direct ecological contact pathway. When a contaminated site is bordered by a more sensitive land use, the vapour inhalation guidelines (soil and groundwater) and the groundwater direct ecological contact guideline for the more sensitive land use apply to the contaminated site anywhere within 30 m of the more sensitive property boundary (see Figure 1).

2.4.4 Relationship to Air and Water Quality

Soil contamination interacts with air through volatilization and with water through dissolution and leaching to groundwater or runoff to surface water. Mobile soil contamination that is adding contaminant mass to air or water, is automatically considered a source. Therefore it must be remediated, or the contaminant release from the soil must be controlled as noted in Section 2.3.1.

For all land uses except natural areas, the Alberta Tier 1 soil remediation guidelines include soil concentrations that have been developed to protect indoor air quality. When soil contaminant concentrations exceed the soil remediation guideline protective of indoor air, then management of this exposure pathway is required.

The Alberta Tier 1 soil remediation guidelines also include soil concentrations that have been developed to protect groundwater quality. When soil contaminant concentrations exceed the soil remediation guideline protective of any groundwater-governed pathway (e.g., protection of potable groundwater for drinking water, protection of groundwater for freshwater aquatic life, or other groundwater pathways), then an investigation of groundwater quality is required unless the groundwater pathway can be managed under a Tier 2 approach. Tier 2 approaches could include pathway exclusion, site-specific risk

assessments, or guideline adjustments based on separation distances between the zone of contamination and the seasonally high saturated zone or the distance to the water body of concern (see AENV, 2008a; Part B, Section 3). A groundwater quality investigation is also strongly recommended when contaminant concentrations in soil are close to the groundwater protection guidelines because the presence of preferential flow paths can result in contaminants reaching groundwater even when general soil conditions appear not to pose a risk. It is also possible that mobile substances have leached out of the vadose zone into groundwater if sufficient time has elapsed since the release event. The purpose of the groundwater quality investigation is to determine if there is groundwater contamination resulting from associated contaminated soil rather than to monitor groundwater quality over time.

2.4.5 Relationship to Land Application of Organic Materials, Industrial By-Products and Pesticides

The *Industrial Release Limits Policy* (AENV, 2000) specifies that substances regulated by Alberta Environment should be managed to prevent soil contamination. Under this policy, Alberta's approach to the management of wastes, industrial byproducts, composts, and other materials is based on the potential to improve soil quality. Wastes that provide no benefits to soil quality must not be applied to land in a manner that causes soil contamination. Industrial byproducts, composts, and other materials that provide a potential benefit to soil quality may be applied to land according to good agronomic or forestry practices and in accordance with any other regulatory requirements. Even when benefits can be shown, any potential contaminants in the byproduct must be managed to prevent their buildup in soil to concentrations that exceed Tier 1 or Tier 2 guidelines. Soil is a biologically active medium and is sometimes used as a treatment medium for soil contaminated by biodegradable substances. Land treatment of soil contaminated by gasoline, diesel fuel, jet fuel and kerosene is allowed if registered in accordance with the *Code of Practice for Land Treatment of Soil Containing Hydrocarbons* (AENV, 2008b).

Tier 1 guidelines are used to evaluate chemical concentrations in soil. They can also be used to evaluate chemical concentrations resulting from the mixing of industrial by-products or organic materials into soil. They should not be used to evaluate concentrations in the by-product or organic material itself, unless the material will be placed directly on land without being mixed with soil.

Tier 1 pesticide guidelines have been developed for a limited number of exposure pathways for which sufficient information is available. These values are intended for use in the remediation of pesticide contaminated sites and not for restricting pesticide use in accordance with registered application rates.

Disposal and treatment of wastes generated by the upstream oil and gas industry are regulated by the Alberta Energy Resources Conservation Board in accordance with Directive 50, *Drilling Waste Management* (ERCB, 1996a) and Directive 58, *Oilfield Waste Management Requirements for the Upstream Petroleum Industry* (ERCB, 1996b). Directive 50 Equivalent Salinity Guidelines (AENV, 2007) can be used to assess and remediate drilling waste disposal areas for reclamation certification.

2.5 Groundwater Protection in Alberta

2.5.1 Alberta's Initiatives to Protect Water Resources

Water is a public resource, and is owned and regulated by the Government of Alberta. Alberta is facing pressures on its water resources as a result of population growth, drought, and agricultural and industrial development. In response to these stresses, the Alberta Government in collaboration with Albertans developed *Water for Life: Alberta's Strategy for Sustainability* (Government of Alberta, 2003). *Water for Life* is a comprehensive strategy for addressing water management concerns for the future that emphasizes knowledge and research, partnerships, and water conservation. The protection of groundwater and surface water quality is a key element in the *Water for Life* approach.

The three primary goals of *Water for Life* are ensuring:

- a safe, secure drinking water supply,
- healthy aquatic ecosystems, and
- reliable, quality water supplies for a sustainable economy.

Groundwater has many beneficial uses and an important role in drinking water, the economy and supporting healthy aquatic ecosystems. Approximately 25 percent of Alberta's population depends on groundwater, and groundwater is used in a wide variety of industrial and commercial activities. Groundwater discharges into surface water bodies, such as rivers and wetlands, supporting aquatic ecosystems. Because groundwater and surface water are integrally connected, groundwater cannot be managed in isolation from surface water and aquatic ecosystems.

A key element of *Water for Life* is the protection of water resources. In the protection of groundwater quality, the strongest emphasis is placed on preventing groundwater resources from becoming contaminated. However, where contamination of this valuable public resource has resulted in an exceedance of Tier 1 or Tier 2 guidelines, it must be remediated or managed to ensure on-going protection of human health and the environment, and the restoration of beneficial uses.

This document provides guidance for managing contaminated groundwater in Alberta, and provides risk-based remediation guidelines to indicate when groundwater quality has been restored to an acceptable level.

2.5.2 Protection of Domestic Use Aquifers

Groundwater for domestic use is a significant current and future resource distributed over large geographic ranges in Alberta. Consequently, there is a need to protect the quality of Domestic Use Aquifers (DUAs).

The definition of a DUA is dependant on the amount of water an aquifer can produce, rather than the quality of the water in the aquifer, recognizing that technological treatment methods exist that can reduce or remove natural background substances.

Furthermore, an aquifer does not have to be currently used for domestic purposes in order to be classified as a DUA, as the intent is to define and protect these aquifers for current and future use. Alberta Environment may consider any body of groundwater above the Base of Groundwater Protection[1] that is capable of a sufficient yield of water to be a DUA.

For the purpose of selecting and applying a groundwater guideline for human health protection by ingestion, a DUA is defined as a geologic unit (either of a single lithology or inter-bedded units) that is above the Base of Groundwater Protection having one or more of the following properties:

- A bulk hydraulic conductivity of 1 x 10^{-6} m/s or greater and sufficient thickness to support a sustained yield of 0.76 L/min or greater; or
- Is currently being used for domestic purposes; or
- Any aquifer determined by Alberta Environment to be a DUA.

While it is possible that peat deposits and muskeg may meet the definition of a DUA, based on hydraulic conductivity and unit thickness, Alberta Environment does not consider peat deposits or muskeg to be a DUA because groundwater in them is unlikely to be used as a domestic source.

The DUA drinking water pathway **cannot** be excluded under the Tier 1 Guideline approach. However, using the Tier 2 Guidelines, it is possible to screen out the DUA drinking water pathway under certain circumstances, such as if an isolating geologic unit meeting specific properties is present, or if the only reason a geologic unit meets the definition of a DUA is the presence of a shallow large diameter well. For more information on the criteria for screening out the DUA drinking water pathway, refer to the *Alberta Tier 2 Soil and Groundwater Remediation Guidelines* (AENV, 2008a).

2.5.3 Using Tier 1 Groundwater Remediation Guidelines

The goal of the Alberta groundwater remediation guidelines is to provide numerical targets for the remediation of contaminated groundwater. To ensure consistency with "pollution prevention", a key outcome of Alberta's framework for contaminated sites management, the Tier 1 groundwater remediation guidelines are **not** "pollute-up-to" levels. Sources must not be left uncontrolled until cumulative releases result in an exceedance of Tier 1 or Tier 2 groundwater remediation guidelines. This results only in further contamination, increased remediation costs, and potential loss of water use options. Source control is a crucial component of pollution prevention.

[1] The Base of Groundwater Protection is the depth above which groundwater is naturally non-saline, having a natural concentration of total dissolved solids that is less than or equal to 4000 milligrams per litre. Information on the Base of Groundwater Protection is available from the Alberta Geological Survey.

2.5.4 Background Groundwater Quality

The background concentration of a substance in groundwater is the natural concentration of that substance in a particular groundwater zone in the absence of any input from anthropogenic activities or sources. In some situations, the background concentration of some substances can be a significant proportion of, or even exceed the Tier 1 remediation guideline. Remediation of groundwater to below background conditions is not feasible and is not required. Accordingly, it is important to have a good understanding of background groundwater conditions at a site.

Background concentrations will be specific to the groundwater zone being considered, and will vary both spatially and temporally. To gain a good understanding of background conditions at a site it is necessary to consider groundwater quality data from several monitoring wells installed in the zone of interest, located up- or cross- gradient from any contaminant sources. The more time-series data that are available, the better the understanding of background conditions will be.

Care should be taken to distinguish between apparent background concentrations that are the result of diffuse anthropogenic sources, and true, natural background conditions. In comparing against background, emphasis should always be placed on ensuring that anthropogenic sources are not identified as natural background.

2.5.5 Relationship to Soil, Air and Surface Water

Environmental media are interconnected. Contaminants in soil may leach into pore water or groundwater. Volatile compounds in groundwater may volatilize at the water table and can migrate through the soil into the interior space of buildings above. Soluble contaminants in groundwater can be transported laterally with the groundwater flow, and potentially enter a surface water body (creek, slough, lake, etc.) at the point of groundwater discharge.

Alberta Tier 1 groundwater remediation guidelines are developed to protect indoor air quality, plants and soil invertebrates, and water quality for a range of uses. Guidelines to protect a particular water use are calculated based on the corresponding water quality guideline (drinking water, aquatic life, irrigation, or livestock or wildlife watering).

2.5.6 Points of Compliance

For the purpose of this document, a point of compliance is the spatial location in an aquifer at which a groundwater quality guideline must be achieved to protect human and ecological receptors, to protect a groundwater resource, or to meet other conditions such as industrial use or groundwater management guidelines.

At one extreme, the compliance point could be established at the point of exposure such as a drinking water well (human-ingestion) or a river (ecological-aquatic life). However, this would imply that there could be deterioration in the quality of the groundwater between the contaminant source and the receptor, which could be judged unacceptable in terms of legislative requirements and/or restriction of potential future use of a

groundwater resource. At the other extreme, a precautionary approach could set the groundwater compliance point directly beneath the contaminant source. This is likely to result in a more stringent remedial target concentration and may be unnecessary, as certain exposure pathways may be irrelevant at that particular location, the contaminated groundwater may never reach a receptor, or contaminants may be significantly attenuated in groundwater prior to reaching the exposure point.

To address both conditions, some fundamental principles are used to guide decisions for setting groundwater remediation guidelines and compliance points on individual sites in Alberta.

A DUA, as defined in Section 2.5.2, is an important current and future groundwater resource and must be protected to the maximum extent possible. The compliance point for the human health water ingestion pathway is everywhere within a DUA.

Groundwater aquifers can be an important current or potential future agricultural groundwater resource used for livestock watering and irrigation. For livestock watering, the compliance point is everywhere within the relevant livestock watering aquifer existing below agricultural or other grazing land. For irrigation, the compliance point is everywhere within the irrigation-use aquifer, where applicable.

Ecological receptors must be protected at key exposure points. For aquatic life or wildlife receptors, the minimum point of compliance is at the point of groundwater discharge into a surface water body that is capable of supporting an aquatic ecosystem. Groundwater guidelines are calculated to achieve this. Therefore, the groundwater at all points of groundwater discharge immediately adjacent to the aquatic water body must meet the aquatic surface water quality guideline. For terrestrial receptors (plants and soil invertebrates), the point of compliance is everywhere within the shallow groundwater zone (i.e. the extent of groundwater less than 3 m below ground surface) and at the point of ground surface discharge.

3. ALBERTA FRAMEWORK FOR THE MANAGEMENT OF CONTAMINATED SITES

3.1 Implementation Framework and Management Levels

The general framework for the management of contaminated sites in Alberta has three options and is illustrated by the flowchart presented in Figure 2. A more detailed framework specific to site management under the Tier 1 approach is presented in Figure 3. A brief description of the framework is provided below; a detailed discussion of the management and technical aspects of the Tier 1 guidelines is presented in subsequent sections of the document.

Under the Alberta framework, three options are provided for the management of contaminated sites as the proponent proceeds from initial site assessment to regulatory closure. The three options are:

- Tier 1 - generic remediation guidelines.
- Tier 2 - site-specific remediation guidelines based on the modification of Tier 1 guidelines.
- Exposure Control - risk management through exposure barriers or administrative controls based on site-specific risk assessment.

Regardless of the option chosen, the target level of human health and ecological protection afforded by Tier 1, Tier 2, or Exposure Control is the same.

As discussed below, regulatory closure is available for sites managed to achieve Tier 1 and Tier 2 remediation guidelines. This means that no conditions are imposed on future use of the site, within a given land use. The three management options are briefly described in the following paragraphs:

Tier 1 – Generic Remediation Guidelines

Generic guidelines are based on identification of the receptors to be protected under various land uses, the applicable exposure pathways, and a corresponding set of parameters that allow reasonably conservative predictions of risk at sites throughout Alberta. Whenever possible, models that incorporate toxicity information, receptor characteristics, and fate and transport mechanisms are used to derive Tier 1 guidelines. Risk-based assessments have not been completed for fluoride, sulphur, antimony, beryllium, boron, cobalt, molybdenum, silver, and tin. The Tier 1 guidelines for these compounds are based on professional judgment. Other compounds have been evaluated for only a limited number of exposure pathways. Where site assessments identify the presence of other influential exposure pathways related to these substances, Tier 2 guidelines may need to be developed.

Tier 1 guidelines are expected to be applicable to the majority of contaminated sites in Alberta, although site managers may choose a Tier 2 approach to incorporate more site information in the development of remediation guidelines. There may be some situations

where site conditions result in a *more* sensitive scenario than is captured by the conservative generic scenarios (e.g., a site underlain by very coarse sand and gravel with a high hydraulic conductivity). Information on situations where Tier 1 is not applicable is provided in Section 5.1.6. In such cases, a Tier 2 or Exposure Control approach will be required. Where the Tier 2 approach is required under section 5.1.6, it can be restricted to the specific pathway/receptor relationships that are in question. Even at sites that eventually use a Tier 2 or Exposure Control approach, Tier 1 guidelines are normally used for an initial screening as the first step in a phased site assessment.

The Tier 1 process comprises an initial site assessment and characterization followed by the selection of the applicable Tier 1 guidelines. If feasible and appropriate, remediation management to Tier 1 guidelines will be undertaken. When a proponent believes Tier 1 remediation management is not feasible and/or appropriate, the proponent may proceed to the Tier 2 process or, in some cases, to Exposure Control. The use of Tier 1 guidelines is described further in Section 5.

Tier 2 - Modified Generic Remediation Guidelines

There may be circumstances where site-specific conditions modify potential human and ecological exposure, relative to the generic conditions used to derive Tier 1 guidelines, such that the generic guidelines are unnecessarily conservative. Alternatively, site-specific conditions may increase risks to a level that renders a Tier 1 approach unacceptable. Accordingly, guidance is provided in the companion Tier 2 document (AENV, 2008a) on ways in which Tier 2 guidelines can be developed. The Tier 2 guidelines will normally be determined by screening out exposure pathways that are not present or by adjusting the Tier 1 models using site-specific values for certain parameters. In either case a more detailed site assessment will be required. Other approaches to calculating Tier 2 guidelines may be allowable, as long as they do not require any form of engineered, administrative, or other exposure control.

Sites where major adjustments to parameters or models are needed may require site-specific ecological risk assessment and/or human health risk assessment to develop appropriate remediation objectives. Quantitative risk assessment is a complex process with intensive data requirements. Complex risk assessments that do not require restrictions to the typical activities considered under a given land use and do not require ongoing risk management may be acceptable for regulatory closure under the Tier 2 process. However, these sites may have additional assessment, monitoring, and/or regulatory requirements that are beyond the scope of this guidance document.

Exposure Control - Risk Management

Exposure Control relies on ongoing risk management to control risks to human health and the environment. This management option is used for sites that require restrictions to the typical activities considered under a given land use or require ongoing risk management.

3.2 Land Use Definitions

For the purpose of developing and implementing soil and groundwater remediation guidelines in Alberta, five generic land uses have been defined – natural areas, agricultural, residential/ parkland, commercial and industrial. A generic land use scenario is envisioned for each category based on typical activities on these lands. The five land uses are defined for the purpose of this document only. Where allowable land uses, as defined by a given jurisdictional authority, differ from those noted here, an assessment of allowable receptors and potential exposure pathways must be made to ensure consistency with assumptions based on definitions here. Where a more sensitive receptor or exposure pathway is allowed, the more sensitive land use description must be used in selecting the appropriate Tier 1 guidelines. Assessors must determine the full range of uses allowed under the applicable zoning bylaw when determining the appropriate land use for Tier 1 application. For most sites in Alberta, one of the five generic land use scenarios should be applicable. If none of the generic land uses are applicable, a site-specific Tier 2 approach will be required. The five land uses are defined as follows:

Natural Areas

Natural areas are defined as being away from human habitation and activities, where the primary concern is the protection of ecological receptors. Accordingly, human exposure pathways are not considered, with the exception of the protection of groundwater for drinking water pathway that, based on the definition of a DUA (Section 2.5.2), applies in all land uses. Much of Alberta's forested land will fall into natural areas land use. Forested lands that are specified as grazing leases represent a special case that requires an amendment to the normal exposure scenario for natural areas. On such grazing leases, the livestock soil ingestion and protection of groundwater for livestock pathways must be addressed in addition to the regular pathways considered under natural areas land use. Natural areas land use must not be applied to areas that may reasonably be expected to be developed, such as those near municipalities and permanent dwellings.

Agricultural Lands

On agricultural land the primary land use is growing crops or tending livestock as well as human residence. This also includes agricultural lands that provide habitat for resident and transitory wildlife and native flora. To allow unrestricted future use of the land, a farm residence is assumed to be present anywhere on agricultural land.

Residential/Parkland

The primary activity on residential/parkland is residential or recreational activity. This land use includes campground areas and urban parks, but not wildlands in provincial parks, which are considered natural areas. Where urban parks are frequented by wildlife, wildlife exposure pathways should be addressed.

Commercial Land Use

On commercial land, the primary activity is commercial (e.g., shopping mall) and all members of the public, including children, have unrestricted access. Commercial land use includes day-care centres, buildings for religious services, hospitals, and medical centres. Commercial land does not include operations where food is grown directly in impacted soil on the site. Such operations would fall under agricultural land use.

Industrial Land Use

Industrial land is land where the primary activity is the production, manufacture or construction of goods. Public access is restricted and children are not permitted continuous access or occupancy.

3.3 Groundwater and Surface Water Use Definitions

Soils are hydrologically linked to groundwater and surface water systems. One of the objectives of Alberta's soil remediation guidelines is to manage soil-to-groundwater pathways to prevent unacceptable transfer of contaminants from the soil, which may ultimately affect groundwater and surface water use. Alberta's groundwater and surface water quality guidelines are representative of allowable chemical concentrations in groundwater or surface water at the point of compliance (see Section 2.5.6).

Alberta guidelines have been developed for four generic uses of groundwater or surface water affected by groundwater discharge:

- human consumption (potable water);
- aquatic life;
- livestock and wildlife watering; and,
- irrigation

These water uses are linked to land uses through the definitions of the generic land use categories. Other water use categories, for example recreation, as well as variations in water use within a defined land use category, may be addressed using the Tier 2 process.

3.4 Conditions and Restrictions Associated with Tier 2 and Exposure Control

The Alberta soil and groundwater remediation guidelines and implementation framework are intended to provide the same high level of protection of human health and the environment at all levels or tiers of site management. For Tier 1, this is ensured by the use of relatively conservative assumptions in the derivation of the risk-based numerical guidelines, such that the values can be applied to the large majority of sites within a land use category without condition or restriction. In other words, the normal activities associated with a particular land use are protected without the need for ongoing management of the site or of contaminants which may be present. Alberta Environment will provide regulatory closure for a site complying with the Tier 1 guidelines, unless site conditions are unsuitable for their application (see section 5.1.6).

Management under Tier 2 guidelines delivers the same level of health and environmental protection by incorporating site-specific data into the development of appropriate remediation guidelines. Sites remediated to Tier 2 guidelines are eligible for regulatory closure.

Certain types of site-specific data or assumptions dictate the need for ongoing site management to ensure that the assumptions used to assess human and ecological risks or to develop site-specific objectives remain valid. Ongoing management of a site, or of the contaminants present, will generally invoke a land use restriction or condition that will preclude regulatory closure. Therefore site-specific adjustments or assumptions that would trigger ongoing management requirements can only be implemented under the Exposure Control option.

To avoid the need for ongoing management and, hence, possible conditions and land use restrictions, Tier 2 adjustments are usually limited to parameters that are measurable and stable, such as soil properties, geological conditions, hydrogeology and distances to natural surface water bodies. Tier 2 assessments that involve full site-specific risk assessment using models and assumptions that may differ from those used in the calculation of the Tier 1 guidelines may be accepted provided they do not require any form of ongoing risk management. Parameters that are unique to current site use, an existing development or the location of a receptor, such as the characteristics of a site building or the distance to a water well, may change in the future thereby invalidating the site-specific assumptions. Adjustments of such parameters are not allowed at Tier 2. In some cases exposure pathways may be inoperative under a particular site use (e.g. direct human or ecological contact with contaminated soil at a commercial site that is paved or capped) or the frequency of exposure may differ from the generic assumptions. Preservation of these conditions would require ongoing management; therefore these adjustments cannot be made at Tier 2. Further guidance on parameters and assumptions eligible for adjustment at Tier 2 is provided in the companion Tier 2 document (AENV, 2008a).

4. SCIENTIFIC BASIS FOR DEVELOPING TIER 1 REMEDIATION GUIDELINES

4.1 Risk-Based Guidelines

Risk-based guidelines are developed with the understanding that for risk from chemical contamination to exist, all of the following elements must be present:

- the substance must possess toxic properties;
- the substance must be present in the environmental medium of concern (soil or groundwater);
- a receptor must be present (human, livestock, crop, or ecological receptor); and,
- there must be an exposure pathway through which the substance can reach the receptor and be taken in to the receptor's body.

Risk-based guidelines are then calculated by first determining the amount (dose or concentration) of substance to which a receptor can be safely exposed. Next, for each exposure pathway, a conservative estimate is made of a concentration of the substance in soil or groundwater that will protect the receptor from exposure exceeding the safe amount. These substance concentrations are referred to as risk-based guidelines and represent remediation objectives for the protection of human and ecological health on contaminated sites.

4.1.1 Steps in the Development of Tier 1 Risk-Based Guidelines

The steps in the development of the risk-based guidelines in Tables 1, 2 and 3 are as follows.

1. Identification of the potential receptors and the potential exposure pathways through which contaminants can come into contact with receptors (e.g., humans or ecological receptors such as livestock, crops, and wildlife).
2. Identification of appropriate protection endpoints for each exposure pathway/receptor combination.
3. Calculation of a substance concentration in soil and/or groundwater (guideline) for each exposure pathway that offers a safe level of protection.
4. Determination of an overall Tier 1 risk-based guideline for soil and/or groundwater by selecting the lowest of the guidelines calculated for all relevant exposure pathways.

The remainder of Section 4 describes how these four steps were implemented in the development of the Tier 1 soil and groundwater remediation guidelines. The details of the calculations used in Step 3 are provided in Appendix C.

4.2 Protection of Human Health

4.2.1 Human Receptors and Exposure Pathways

In establishing appropriate risk-based guidelines, the most sensitive user of a contaminated site must be considered and protected. The most sensitive receptor is normally a function of the degree of potential exposure, the exposure pathway(s) and the substance(s) of concern. For the application of Tier 1 and Tier 2 guidelines, the land use and contaminant characteristics will dictate the critical receptor. When developing Tier 1 and Tier 2 guidelines, people of all ages are assumed to be present on agricultural, residential/parkland and commercial land. At industrial sites, only employees are assumed to be routinely present, which precludes the exposure of children. Human receptors are assumed to be absent in natural areas, although underlying groundwater is considered to be a potential source of drinking water.

The following human exposure pathways are considered when developing and implementing Tier 1 and Tier 2 remediation guidelines (based on CCME, 2006). The exposure pathways are applicable to all land uses, except where noted below.

Direct Contact

Humans coming into direct contact with contaminated soil via incidental ingestion, dermal contact, or inhalation of air-born soil particles. Applicable to all land uses except natural areas.

Drinking Water

Humans drinking from and showering or bathing in water that is sourced from groundwater. Applicable to all land uses.

Inhalation

Volatile contaminants being released from soil and/or groundwater and migrating upwards into living or working spaces where humans are exposed via inhalation. Applicable to all land uses except natural areas.

Off-Site Surface Migration by Wind or Water Erosion

The soil quality guideline for commercial and industrial land use may be greater than the corresponding guideline for more sensitive land uses. Wind or water transport of contaminated soil from a commercial or industrial site onto an adjacent site with a more sensitive land use could potentially result in contaminant concentrations that exceed the human direct contact soil quality guideline applicable to the more sensitive land use. The off-site migration check is calculated to ensure that the commercial or industrial guidelines set are protective of this exposure pathway.

4.2.2 Human Health Protection Endpoints

The human health protection endpoint is the same at all tiers of management, and is expressed in terms of an allowable exposure level at which the likelihood of a receptor

experiencing adverse health effects is essentially negligible. Specifically, the level of human exposure to a threshold chemical (i.e., non-carcinogen) must not exceed the tolerable daily intake specified by Health Canada or other appropriate regulatory agency, including background exposure to the chemical. For a non-threshold chemical (i.e., carcinogen), the incremental lifetime cancer risk must not exceed 1 in 100,000 (1×10^{-5}), the value considered by Health Canada to be essentially negligible (Health Canada, 2004).

4.3 Ecological Protection

4.3.1 Ecological Receptors and Exposure Pathways

Risk-based guidelines fulfill two main goals from the ecological standpoint: protection of ecological receptors expected to be present at a site based on land use, and preservation of an appropriate level of ecological function of the site and its ecosystem components.

Ecological receptors at a typical contaminated site, within the range of generic land uses considered in the development of the Alberta guidelines, span a range of trophic levels including soil-dependent organisms (plants, including crops, and soil invertebrates) and higher order consumers (terrestrial and avian wildlife and livestock). In addition, based on the potential for groundwater underlying a site to discharge to a surface water body that is capable of supporting an aquatic ecosystem, aquatic receptors including invertebrates, fish, and aquatic plants are considered. Receptors assigned to each land use for the purpose of guideline derivation must be both ecologically relevant to a site and sufficiently sensitive to be representative of the range of receptors normally present. In addition to the protection of ecological receptors *per se*, ecologically based guidelines must be protective of other processes such as nutrient cycling and related microbial activities.

The following ecological exposure pathways are considered in the determination and implementation of Tier 1 remediation guidelines where appropriate to the defined land uses (based on CCME, 2006).

Direct Contact

Plants and soil invertebrates coming into direct contact with contaminants in soil or shallow groundwater. Direct contact is applicable to all land uses. This pathway may be eliminated below 3 m for petroleum hydrocarbon fractions 1 to 4 only.

Nutrient and Energy Cycling

This exposure pathway examines the microbial functioning of the soil, including carbon and nitrogen cycling. Applicable to all land uses.

Livestock/Wildlife Soil and Food Ingestion

Livestock or wildlife ingesting contaminants via the incidental ingestion of soil and ingesting contaminants that have bioaccumulated from soil into fodder. Applicable to agricultural and natural area land use only.

Aquatic Life

Aquatic life, including fish, aquatic invertebrates and aquatic plants, being exposed to contaminants when groundwater discharges to a surface water body that is capable of supporting an aquatic ecosystem. Applicable to all land uses.

Irrigation

Crops being exposed to contaminants when groundwater is used for irrigation. Applicable to agricultural land use only.

Livestock/Wildlife Watering

Livestock or wildlife being exposed to contaminants when groundwater is used for livestock watering, or groundwater discharges to a surface water body where wildlife may drink. Applicable to agricultural and natural area land use only.

4.4 Calculation of Guidelines

Soil remediation guidelines were calculated for each land use and soil texture using models consistent with the latest CCME (2006) protocols. In some cases, more recent deliberations of the Sub-Groups supporting the 2007 revision of the Petroleum Hydrocarbon Canada-Wide Standard (PHC CWS; CCME, 2008) have resulted in revisions to parameter values, and these revisions have been adopted in the current document. Parameter values were adapted for Alberta conditions and policies where appropriate. Groundwater remediation guidelines were calculated for each water use by adapting the models from the soil remediation guideline calculations, as appropriate. Details of all models and parameters used are provided in Appendix C.

4.5 Determination of Overall Guideline

Tier 1 guidelines are intended to be a conservative screening tool. The lowest of the guidelines (tabulated in Appendix A and B) calculated for applicable exposure pathways and the appropriate land use and soil texture is the overall Tier 1 remediation guideline (Tables 1, 2, and 3). At some sites, it may be possible to demonstrate that certain exposure pathway(s) are not relevant, and exclude the corresponding objective for those pathway(s) using a Tier 2 approach. Conditions for excluding particular exposure pathways are provided in the companion document describing Tier 2 procedures (AENV, 2008a).

4.6 Integration of New and Existing Guidelines

New risk-based guidelines were calculated for a wide range of organic compounds in this document using the latest CCME (2006) protocols (in some cases modified based on the 2007 revisions to the PHC CWS) and adapted for Alberta conditions and policies (Tables 1, 2, and 3). Guidelines were not recalculated for inorganic compounds, except arsenic; existing risk-based guidelines were retained from Canadian Environmental Quality Guidelines (CCME, 1999 and updates). Existing guidelines for the soil ecological contact pathway and the soil and food ingestion pathway were also retained where they existed, or were recalculated in the case of soil ingestion guidelines for certain hydrocarbons. Soil remediation guidelines based on professional judgment were retained from previous guideline documents for antimony, beryllium, boron, cobalt, fluoride, molybdenum, silver, elemental sulphur, and tin because risk-based Alberta Tier 1 guidelines have not yet been developed for these substances. Guidelines for these substances were adopted from the *Alberta Tier 1 Criteria for Contaminated Soil Assessment and Remediation* (AEP, 1994) for natural areas, agricultural, and residential/parkland land uses. For commercial and industrial land uses, and for all uses if the substance was not included in AEP (1994), guidelines were adopted from the *Interim Canadian Environmental Quality Criteria for Contaminated Sites* (CCME, 1991). Soil remediation guidelines for electrical conductivity and sodium adsorption ratio (Table 4) were adopted from the *Salt Contamination Assessment and Remediation Guidelines* (AENV 2001c).

5. USER GUIDANCE FOR TIER 1 MANAGEMENT

The process for implementing the Alberta Tier 1 soil and groundwater remediation guidelines is illustrated schematically by the flow diagrams presented in Figures 2 and 3. Detailed guidance for Tier 2 is provided in a companion document (AENV, 2008a) and is summarized herein.

As illustrated in Figures 2 and 3, Tier 1 management is divided into three stages: assessment, evaluation, and decision/management. These three stages are discussed in the following sections.

5.1 Information Requirements for Tier 1 (Tier 1 Assessment)

5.1.1 Overview of Requirements

A preliminary site characterization is required for all Tier 1 assessments. Site characterization must be comprehensive enough to adequately describe site conditions and address all assessment and management options within the scope of Tier 1.

The Tier 1 assessment may be more comprehensive and detailed, at the discretion of the proponent, providing additional information for potential use in developing Tier 2 guidelines. While there are advantages associated with a phased approach to site assessment, there may also be economies in combining data collection activities into a single investigation, particularly at locations where mobilization and demobilization costs are significant.

The minimum data requirements for a Tier 1 site assessment include:

Land Use and Sensitivity Factors

- site description;
- land use, including the full range of uses allowed under the applicable zoning bylaw;
- proximity of the site to surface water and drinking water supplies;
- actual and potential uses of groundwater;
- human receptors; and,
- ecological receptors.

Physical Conditions

- soil particle size;
- stratigraphy and properties of surficial materials;
- depth to groundwater; and,
- presence and types of buildings and other structures.

Contaminant Characteristics and Distribution

- contamination characterization; and,
- horizontal and vertical extent of contamination.

The above information is generally required at all tiers, to a level of detail appropriate for the requirements of the evaluation and decision stages of each tier.

5.1.2 Land Use and Sensitivity Factors

One of the objectives of the Tier 1 site assessment is to determine whether the site broadly fits any of the five generic land use categories. In this regard, the minimum data requirements for a Tier 1 assessment are as follows:

Site Description

The site description must include basic identifying data such as location and legal description, site dimensions, registered owner(s) etc., as well as a description of the physical surface expression of the site (surface topography), vegetative cover, nature of site development and, where applicable, site history.

Land Use

In determining land use, consideration must be given not only to present land use but also to historic and potential future land uses. Land use on private land is normally prescribed by the current and/or future zoning of the land and local development trends. Land use for public land is determined by the land manager who will use resource based input and tools such as land reservations and integrated plans as guidance. Attention must be given to all uses allowed under the applicable zoning bylaws and land use decisions.

Sufficient descriptive and legal or administrative information must be obtained to determine the generic land use category (natural areas, agricultural, residential/parkland, commercial, industrial) and whether the land use may be considered typical for the assigned category. The five generic land uses are defined and described in Section 3.2.

Land uses of adjacent or nearby properties must also be documented, as the presence of more sensitive off-site land uses may drive the site management requirements. Where a contaminated site on a less sensitive land use borders, or lies within 30m, of a more sensitive land use, the vapour inhalation guidelines (soil and groundwater) and the groundwater direct ecological contact guidelines for the more sensitive land use must be applied to the contaminated site within 30 m of the more sensitive land use boundary (see Figure 1).

Proximity of Site to Surface Water and Drinking Water Supplies

The assessment must document all existing and potential uses of groundwater and surface water, including their locations. The distance beyond which water uses are not significant or relevant depends on site-specific conditions but, as a minimum for Tier 1, water uses within 300 m should be identified. If the direction of groundwater flow has

been reliably determined by site-specific groundwater monitoring, documentation of water uses can be limited to 100 m upgradient and 300 m down gradient of the site. Flood risk areas should be taken into account when considering distance to surface water receptors. For more information see the companion Tier 2 document (AENV, 2008a).

The distance of 300 m was selected as being greater than the length of the majority of groundwater plumes of dissolved petroleum hydrocarbon. This value is based on studies of hydrocarbon plumes in the upstream oil and gas industry in western Canada undertaken by the Consortium of Research on Natural Attenuation (CAPP, 2002). The value of 300 m is also consistent with a compilation of 647 petroleum hydrocarbon plumes presented in Wiedemeier *et al.* (1999), in which it was determined that 98.1% of the plumes were less than 900 feet (274 m) long.

Water uses at greater distances must be considered on a case-by-case basis when subsurface conditions are such that adverse impact may be possible. For example, plumes of conservative soluble compounds that do not interact with the soil matrix, such as chloride, may travel farther than dissolved hydrocarbons (CAPP, 2002). Municipal water supply wells located more than 300 m from a site might be expected to be at risk from a contaminant source located anywhere within the zone of capture of the wells.

The assessment must recognize that, while the locations of most natural surface water bodies are essentially fixed, seasonal water bodies may exist at other locations, and anthropogenic groundwater uses could be initiated at any location relative to the site, in areas of usable groundwater.

Human and Ecological Receptors

In general, the presence of human receptors will be directly related to the land uses. However, sufficient information must be obtained to determine whether the land use is typical of the respective category, or whether receptors are present that would warrant a variation from the defined generic land use categories.

5.1.3 Physical Conditions

Certain physical conditions and parameters must be determined to permit the implementation of Tier 1 management. The minimum physical data requirements are discussed below.

Soil Particle Size

As a minimum, since Tier 1 guidelines are prescribed for coarse-grained and fine-grained soils, sufficient particle size information should be obtained to permit classification of the soils as either coarse or fine. Fine-grained soils are defined as having a median grain size of less than or equal to 75 µm; coarse-grained soils have a median grain size of greater than 75 µm. The absence of sufficient particle size information will result in the default application of the more conservative Tier 1 guideline for each substance. Where both fine and coarse grained strata are present, the dominant soil particle size is determined by the stratum governing horizontal and vertical migration to a receptor.

Soil Stratigraphy and Physical Properties

Information on soil stratigraphy and physical properties is normally obtained by means of an intrusive subsurface investigation, although preliminary, qualitative information can often be obtained from other sources including published surficial geological information or the results of other subsurface investigations conducted in the area. In certain circumstances, it may be possible to apply the Tier 1 guidelines without a prior subsurface investigation. For example, the decision could be made to manage a spill of limited extent by removing all materials containing contaminant concentrations in excess of Tier 1 guidelines. Confirmation of the degree and extent of impact, as well as the subsurface conditions, could be obtained at the time of soil excavation. However, subsurface investigations are commonly conducted to support the application of Tier 1 guidelines, in part for the purpose of contaminant characterization and site management planning.

The Tier 1 assessment must provide an overall description of the subsurface soil conditions and their vertical and lateral variability. Of particular importance is the uniformity of the soil particle size and the presence of any depositional or structural features, such as lenses or fissures, that could influence the fate and transport of certain chemicals in the subsurface. Where there are multiple geological deposits falling into both the coarse and fine definition such that the particle size dominating transport cannot be determined, the Tier 1 guidelines must default to the most stringent option.

Hydrogeological Conditions

A hydrogeological investigation will normally form part of any subsurface investigation. Although soil guidelines have been developed to protect groundwater for various uses, care must be taken in using them to assess risk to groundwater at contaminated sites. Soils are heterogeneous. Variations in contaminant concentration and soil lithology and the presence of preferential flow paths can result in contaminants reaching groundwater even when general soil conditions appear not to pose a risk. It is also possible that mobile substances have leached out of the vadose zone into groundwater if sufficient time has elapsed since the release event. Alberta Environment strongly recommends that groundwater quality be investigated when contaminant concentrations in soil are close to the groundwater protection guidelines. The cost of installing groundwater monitoring wells can be minimized if they are installed when soil boreholes are drilled.

Information must be collected on depth to groundwater table, groundwater flow direction, hydraulic gradient and, with the appropriate field tests, hydraulic conductivity. While all of these parameters are influential, their quantitative determination is not required for the basic implementation of Tier 1, and qualitative information may be available from other sources. However, as with soil parameters, they can facilitate the decision between managing to Tier 1 guidelines or developing Tier 2 remediation guidelines or Exposure Control options.

For some substances, groundwater chemical characteristics are required for the development of a groundwater guideline. Where this applies, Table 2 references the

Surface Water Quality Guidelines for Use in Alberta (AENV, 1999) for further information on the chemical data required.

Buildings and Other Structures

When volatile substances are present, the site assessment must identify presence of buildings. When a building is not present, but the municipal zoning allows one to be built, its presence must be assumed. Site assessments must also consider the presence of structures, such as utility corridors and dirt basements, that may require a Tier 2 approach.

5.1.4 Contaminant Characteristics and Distribution

Requirements for site characterization to address all aspects for regulatory requirements or to characterize contaminants that are not included in the Tier 1 guideline process are beyond the scope of this document. It is the responsibility of the proponent to ensure that sufficient site characterization is carried out to address relevant regulatory requirements and to address any potential contaminants of concern not included in the Tier 1 soil and groundwater remediation guidelines. However, for the purposes of applying the Tier 1 guideline tables, the following general guidance can be given.

Sufficient characterization of the contamination must be conducted for the purpose of comparing contaminant concentrations with Tier 1 guidelines. This will normally comprise the collection and laboratory analysis of sufficient soil or groundwater samples to determine representative concentrations. As part of the Tier 1 assessment, the proponent must conduct sufficient sampling to delineate the lateral and vertical extent of impacted soil and groundwater (Fig. 3). An exception is allowed where the contaminated soil is completely removed and confirmatory samples show compliance with Tier 1 guidelines. When confirmatory samples fail to comply with Tier 1 guidelines after excavation is deemed complete, full delineation of the remaining contamination must be undertaken and used to develop further remediation actions or risk management programs. Whether delineating contamination or confirming remediation success, the data collected must be sufficient to support regulatory closure.

5.1.5 Conditions Where Additional Exposure Pathways May Be Applicable

There may be conditions where certain exposure pathways are applicable that would not normally be considered under a given land use. An example of this is a grazing lease within a natural area. In the case of such grazing leases, the livestock soil and food ingestion and protection of groundwater for livestock watering pathways apply in addition to the regular exposure pathways considered for that land use. Adding additional pathways to those typically considered for a land use may be done under the Tier 1 approach, provided no additional site information is needed for the additional pathway. Note that *removing* pathways that may not be applicable for a given land use from the pathways specified for the Tier 1 guidelines is *not* permitted, and may only be done under the Tier 2 approach.

5.1.6 Conditions Where Tier 1 Guidelines Are Not Applicable

Tier 1 guidelines are derived using relatively conservative default parameters and assumptions corresponding to the defined generic exposure scenarios and land use categories. As such, they are intended and expected to be protective of human health and the environment in the large majority of cases. However, there may be situations in which Tier 1 guidelines are not applicable, either where conditions violate one or more assumptions essential to the validity of the modelling used in the Tier 1 derivation, or where actual exposure conditions or receptors at a site are more sensitive than in the generic exposure scenario.

Some examples of situations where Tier 1 guidelines are not applicable are highlighted below. These situations must be addressed through the Tier 2 process. The companion Tier 2 document (AENV, 2008a) should be consulted for further details.

Source of Volatile Contaminants Present Within 30 cm of a Building Foundation

Within this distance, the model used to assess vapour intrusion to buildings is not reliable, and Tier 1 guidelines are not applicable.

Unusual Structural Features

Building features such as earthen floors or unusually low air exchange rates are not considered in the Tier 1 model, and a Tier 2 approach is required. Where very coarse textured materials (see below) are found within utility corridors that are controlling contaminant migration, a Tier 2 approach is required.

Groundwater Flow to Stagnant Water Bodies

Additional consideration is required if groundwater at a site has the potential to discharge to a stagnant water body. A stagnant water body is defined as a water body without significant outflow, and where the main pathway of water loss is via evaporation. Stagnant water bodies will tend to concentrate discharging persistent groundwater contaminants through evaporation. Water bodies with no obvious or known outflow should be considered stagnant. If outflow is suspected via groundwater and no obvious surface outflow is present, a groundwater investigation will be needed to provide confirmation.

In the assessment of whether soil or groundwater contaminants are likely to have an adverse effect on a stagnant surface water body, the current concentrations of contaminants in groundwater are less important than the long-term effect on contaminant concentrations in the stagnant water body. Accordingly, when there is the potential for a contaminant in groundwater to discharge to a stagnant surface water body, a Tier 2 mass balance assessment of the likely concentrations of that contaminant in the stagnant water body over the anticipated lifetime of the groundwater discharge is required. The assessment should take into consideration, in a qualitative sense, the likelihood of other potential future contaminant releases to the stagnant surface water body. Unless the effect on contaminant concentrations in the stagnant surface water body can be shown to be insignificant, remedial action will be required.

Groundwater Within 10 m of a Surface Water Body

Tier 1 soil and groundwater remediation guidelines for the protection of aquatic life assume a minimum separation of 10 m between the point that the soil or groundwater concentration is measured, and the discharge point. Accordingly, Tier 1 guidelines only apply to soil or groundwater located at least 10 m from the nearest surface water body that is capable of supporting an aquatic ecosystem. Within this distance, a Tier 2 approach is required, or in the case of groundwater guidelines, the corresponding surface water freshwater aquatic life guideline may be applied directly to groundwater quality. The 10 m offset distance must take into account potential for seasonal fluctuations in the water level. This may require information on the flood risk area. For more information, see the companion Tier 2 document (AENV, 2008a).

Very Coarse Textured Materials Enhancing Groundwater or Vapour Transport

Groundwater velocity is a function of both hydraulic conductivity and hydraulic gradient and assumed to be $1x10^{-5}$ m/s and 0.028 m/m, respectively, for Tier 1 guideline derivation. The resulting Darcy groundwater velocity is 3×10^{-7} m/s.

The rate of vapour transport through coarse soil is largely governed by vapour permeability which is assumed to be $6x10^{-8}$ cm^2 for Tier 1 guideline derivation.

If the Darcy groundwater velocity exceeds $3x10^{-7}$ m/s, or vapour permeability is greater than $6x10^{-8}$ cm^2 at a site, a Tier 2 approach is required. In these cases, the Tier 2 guideline must incorporate groundwater or vapour inhalation as potentially dominant exposure pathway(s).

Fractured Bedrock

The Tier 1 remediation guidelines were developed for unconsolidated soil material, therefore the presence of bedrock may require a Tier 2 re-evaluation. However, the guidelines may be applied to contaminants in contact with bedrock if the bedrock is likely to behave conservatively as one of the two soil textures. The actual texture of the bedrock material will often be less influential on contaminant movement than the degree of bedrock weathering and fracturing. Professional judgment must be applied in determining whether coarse or fine soil guidelines are the most appropriate, given the expected contaminant mobility within the bedrock. For instance, a weathered shale material may not automatically require a Tier 2 re-evaluation but it may require use of a coarse soil guideline due to the presence of minor fractures within the matrix.

Tier 2 re-evaluation is required where flow paths in the fractured bedrock cannot reasonably be expected to behave similarly to those in an aggregated soil medium. When the fracture length exceeds approximately 2 cm, flow paths in the fractured bedrock may be different than those in an aggregated soil medium. Under such conditions, groundwater transport in fractured bedrock is outside the scope of the calculations for Tier 1 guidelines and a Tier 2 or Exposure Control approach must be taken.

Source Length Greater than 10 m

The model used to develop Tier 1 guidelines for groundwater remediation and protection assumes a source of groundwater contamination that is 3m deep and 10m wide with a length of 10 m parallel to the direction of groundwater flow. Sources are discussed in Section 2.3.1 and include anything that adds contaminant mass to the environment. For the purposes of the groundwater transport model used to develop Tier 1 guidelines, the source length is relevant to sources that are releasing contaminants to groundwater. Source length is determined by soil concentrations that exceed soil guidelines for the protection of groundwater pathways (see Appendix A). When the length of such a source is greater than 10 m parallel to the direction of groundwater flow, Tier 1 guidelines may be applied to the site if contaminant delineation shows that the source volume is less than 300 m^3. Alternatively, if source and site characteristics indicate no potential for groundwater contamination and remediation of the site to Tier 1 guidelines will result in a source length less than 10 m or volume less than 300 m^3, then remediation to Tier 1 objectives may proceed. In all other cases a Tier 2 approach is required. When the contaminated soil is not in contact with the seasonally high saturated zone, a Tier 2 guideline adjustment (AENV 2008a, Part B, Section 3) provides the assessor with an approach for estimating contaminant attenuation between the contaminated zone and the saturated zone.

Organic Soils

When inorganic contaminants occur in organic soils, a Tier 2 approach is required. Organic soils are defined in *The Canadian System of Soil Classification* (Soil Classification Working Group, 1998). Coarse textured soil and groundwater remediation guidelines may be used for organic contaminants in organic soil.

5.2 Identification of Appropriate Tier 1 Guidelines (Tier 1 Evaluation)

5.2.1 Land Use and Water Use Conditions and Primary Soil Type

Land use and water use conditions are established on the basis of the information compiled for the Tier 1 assessment. Land use conditions are compared with the descriptions of the generic land use categories (natural area, agricultural, residential/parkland, commercial, industrial) to assign the site to the most sensitive applicable category. In some instances municipalities or public land managers may allow a range of uses in accordance with zoning bylaws and other land use decisions. These uses must be evaluated with respect to the five land uses described for Tier 1 guidelines. The most sensitive land use will determine Tier 1 guidelines.

Groundwater and surface water use conditions are assigned, if applicable, to one or more of the generic categories of potable water, surface water that is sustaining an aquatic ecosystem, water used for livestock or wildlife watering, and irrigation.

Exceptions to the above categories are discussed in the following section.

5.2.2 Conformity with Generic Land and Water Use Categories

The principal criterion for the application of the Tier 1 guidelines is conformity with the generic land and water use scenarios and exposure conditions assumed in the development of the Tier 1 guidelines, and discussed in Section 3 of this document. It is the responsibility of the proponent to identify and respond to any site or receptor factors that could unduly accentuate exposure or risk beyond that envisioned in the Tier 1 exposure scenarios and, where necessary, move to the Tier 2 approach.

First, the land and water use must normally be encompassed by one or more of the defined generic categories. Examples of land uses not addressed in the development of the Tier 1 guidelines include wetlands and riparian zones. Examples of water uses not directly addressed by Tier 1 include: water used in the food processing industry (although this may be represented by the potable water scenario); and surface water used for swimming or similar recreational activity. In the absence of an applicable Tier 1 standard for the actual land or water use, a Tier 2 approach must be followed.

Second, the exposure conditions associated with the identified land and water use must not be more sensitive or critical than those assumed in the determination of the Tier 1 guidelines. Examples of factors giving rise to greater sensitivity are: a greater frequency or intensity of human or ecological exposure beyond that associated with typical use of the land or water; or, variations in physical site conditions resulting in greater exposure than that assumed (discussed in Section 5.1.6). The human and ecological exposure factors and physical parameters used for the Tier 1 guidelines are presented in Appendix C. These values should be used as the basis for assessing whether site-specific factors are indicative of more frequent or intense exposure.

Ingestion of produce, milk, and meat produced on the site is not included in Tier 1 human exposure estimates because of its site-specific nature. Where a significant portion of an individual's diet is obtained from areas contaminated by substances that bioconcentrate, this exposure pathway must be evaluated with the Tier 2 approach.

5.2.3 Identification of Applicable Tier 1 Guidelines

Tier 1 guidelines for soil and groundwater are presented in Tables 1 through 4. Guidelines in Tables 1 through 3 are presented for coarse-grained and fine-grained soils; selection of the appropriate set of values is based on the texture of the dominant soil type as determined in the Tier 1 assessment. The dominant soil type is that which governs fate and transport via the various transport and exposure pathways. For example, a continuous layer of coarse-grained soil beneath the water table will often govern groundwater flow in the saturated zone, even though its thickness may be small in relation to the total thickness of saturated fine-grained soils. Similarly, a thin layer of fine-grained soil in the unsaturated zone may be a more significant control on the migration of vapours than a thicker layer of coarse-grained soil. Professional judgment should be exercised in establishing the dominant soil type.

The use of subsoil guidelines for petroleum hydrocarbons (Table 3) and salinity (Table 4) may be used at Tier 1 under the following circumstances:

Petroleum Hydrocarbons

Surface soil guidelines for petroleum hydrocarbon fractions F1 to F4, benzene, toluene, ethylbenzene, and xylenes must be applied to a depth of 1.5 m. Subsurface guidelines may be used as follows:

- below 1.5 m in depth within a 5 m setback from an oilfield wellhead (see Municipal Affairs and Housing Advisory Land Use Planning Notes on Abandoned Wellsites) , or
- below 3 m in depth at any site.

Exclusion of the soil and groundwater direct ecological contact pathway is permissible under the Tier 1 approach at any site below a depth of 3 m for petroleum hydrocarbon fractions F1 to F4 only.

Salinity

Topsoil guidelines for electrical conductivity and sodium adsorption ratio must be applied to the L, F, H, O, and A horizons (Soil Classification Working Group, 1998) or equivalent surficial material where these horizons are not present. Subsoil guidelines may be applied below the A horizon or equivalent in lieu of topsoil guidelines. Further information is available in the *Salt Contamination Assessment and Remediation Guidelines* (AENV, 2001c).

For each contaminant, the lowest guideline tabulated in Appendix A and B for the established soil type and identified land use defines the governing exposure pathway/receptor and, hence, becomes the governing Tier 1 guideline. At Tier 1, all exposure pathways for which generic guidelines have been calculated must be considered. If the governing guideline is based on a soil to groundwater or surface water pathway that is not applicable to the site, based on the prior identification of water uses, a Tier 2 approach may be possible, and the companion Tier 2 document (AENV, 2008a) should be consulted.

5.2.4 Additional Guidance for Specific Substances

Salinity

Electrical conductivity (EC) and sodium adsorption ratio (SAR) guidelines are found in Table 4 for topsoil and subsoil. At Tier 1, the objective for salt contaminated site remediation is to return the site to the same rating category as non-contaminated soils of the same type. To apply the guidelines, background samples are needed from uncontaminated soils that are representative of the same type, depth, and landscape position as the contaminated soil on the site. The background samples are used to establish the appropriate rating categories for the site. The range of EC and SAR values for the appropriate rating categories become the remediation objectives for the site.

Further guidance is provided in the *Salt Contamination Assessment and Remediation Guidelines* (AENV, 2001c).

Barite-Barium

Guidelines are provided for both barium and barite-barium. The barium guidelines are intended to apply to all barium sources, and therefore assume that the source is relatively soluble. Barite, a commonly used weighting agent in drilling fluids, is relatively insoluble and therefore guidelines have been developed specifically for this form of barium. To confirm that barium measured in soil samples meets the conditions of low solubility assumed for the barite-barium guidelines, the sample must pass a $CaCl_2$ extraction test. Further information on applying the barite-barium guidelines, including the $CaCl_2$ test, is provided in *Soil Quality Guidelines for Barite: Environmental and Human Health* (AENV, 2004).

Elemental Sulphur

Tier 1 soil remediation guidelines are provided for elemental sulphur. If these values are exceeded, management options include the application of calcium carbonate to control the acidity generated by the oxidation of elemental sulphur. Elemental sulphur can be managed in this way up to a total sulphur concentration of 4%. Further guidance is provided in *Guidelines for the Remediation and Disposal of Sulphur Contaminated Solid Wastes* (AEP, 1996).

Drilling Waste Disposal Areas

Drilling waste disposal falls under the jurisdiction of the Energy Resources Conservation Board. Management and disposal options are provided by Directive 50 (ERCB, 1996). Alberta Environment has developed D50 Equivalent Salinity Guidelines for assessing and remediating drilling waste disposal areas for reclamation certification. Further information is provided in *Assessing Drilling Waste Disposal Areas: Compliance Options for Reclamation Certification* (AENV, 2007).

Polycyclic Aromatic Hydrocarbons (PAH)

Non-carcinogenic PAHs (naphthalene, acenapthene, fluorene, fluoranthene, anthracene, pyrene) have been included as components of petroleum hydrocarbon Fractions 1 to 4. When the sources of hydrocarbon contamination are crude petroleum or refined fuels, separate analysis of non-carcinogenic PAHs is not necessary. Analysis of these PAHs is necessary when dealing with non-petroleum hydrocarbons such as creosote or products such as solvents where individual compounds may be present at a much greater concentration than in crude products or fuels.

5.3 Tier 1 Decision and Management

The Tier 1 decision process is illustrated schematically by the lower part of the flow diagram presented in Figure 3. The process consists of a number of decision nodes. The decision process and criteria at each node are discussed in the following paragraphs.

5.3.1 Comparison of Conditions with Identified Tier 1 Guidelines

If no exceedances are found in the Tier 1 assessment, relative to the identified Tier 1 guidelines, any sources have been removed, and site conditions are consistent with application of Tier 1 process (see Section 5.1), the site can be considered to be in compliance with Tier 1 and no further action is necessary.

If exceedances are found, the proponent enters a decision process whereby the option of managing to Tier 1 guidelines is weighed against the option of proceeding to the Tier 2 approaches. If site conditions preclude application of Tier 1 guidelines (see Section 5.1.6) then the proponent must use the Tier 2 process.

Verification of remediation to Tier 1 or Tier 2 guidelines can achieve regulatory closure.

5.3.2 Assessment of Opportunity for Tier 2

If the default assumptions used in the derivation of the governing Tier 1 guidelines are conservative relative to actual site-specific conditions, the replacement of default assumptions with site-specific data for certain influential parameters may permit the development and implementation of less stringent remediation guidelines without compromising health and environmental protection goals. Furthermore, point-of-exposure measurements, if less than those predicted using the relatively conservative modeling procedures employed to derive the Tier 1 guidelines, may also permit the implementation of less stringent guidelines. In such cases, proceeding to Tier 2 would generally be advantageous, and the companion Tier 2 document (AENV, 2008a) should be consulted.

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TABLES

Table 1. Alberta Tier 1 Soil Remediation Guidelines

Soil Type	Fine					Coarse					Notes
Land Use	Natural Area	Agricultural	Residential/ Parkland	Commercial	Industrial	Natural Area	Agricultural	Residential/ Parkland	Commercial	Industrial	
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	
General and Inorganic Parameters											
pH (in 0.01M $CaCl_2$)	6-8.5	6-8.5	6-8.5	6-8.5	6-8.5	6-8.5	6-8.5	6-8.5	6-8.5	6-8.5	1
Cyanide (free)	0.9	0.9	0.9	8	8	0.9	0.9	0.9	8	8	2
Fluoride	200	200	200	2,000	2,000	200	200	200	2,000	2,000	1
Sulphur (elemental)	500	500	500	500	500	500	500	500	500	500	3
Metals											
Antimony	20	20	20	40	40	20	20	20	40	40	1
Arsenic (inorganic)	17	17	17	26	26	17	17	17	26	26	
Barium	750	750	500	2,000	2,000	750	750	500	2,000	2,000	2
Barite-barium	3,300	3,200	3,200	11,000	41,000	3,300	3,200	3,200	11,000	41,000	4
Beryllium	5	5	5	8	8	5	5	5	8	8	1
Boron (hot water soluble)	2	2	2	2	2	2	2	2	2	2	1
Cadmium	3.8	1.4	10	22	22	3.8	1.4	10	22	22	2
Chromium (hexavalent)	0.4	0.4	0.4	1.4	1.4	0.4	0.4	0.4	1.4	1.4	2
Chromium (total)	64	64	64	87	87	64	64	64	87	87	2
Cobalt	20	20	20	300	300	20	20	20	300	300	1
Copper	63	63	63	91	91	63	63	63	91	91	2
Lead	70	70	140	260	600	70	70	140	260	600	2
Mercury (inorganic)	12	6.6	6.6	24	50	12	6.6	6.6	24	50	2
Molybdenum	4	4	4	40	40	4	4	4	40	40	1
Nickel	50	50	50	50	50	50	50	50	50	50	2
Selenium	1	1	1	2.9	2.9	1	1	1	2.9	2.9	2
Silver	20	20	20	40	40	20	20	20	40	40	1
Thallium	1	1	1	1	1	1	1	1	1	1	2
Tin	5	5	5	300	300	5	5	5	300	300	1
Uranium	33	23	23	33	300	33	23	23	33	300	
Vanadium	130	130	130	130	130	130	130	130	130	130	2
Zinc	200	200	200	360	360	200	200	200	360	360	2
Hydrocarbons											
Benzene	0.046	0.046	0.046	0.046	0.046	0.078	0.073	0.073	0.078	0.078	5
Toluene	0.52	0.52	0.52	0.52	0.52	0.49	0.49	0.49	0.49	0.49	5
Ethylbenzene	0.11	0.11	0.11	0.11	0.11	0.21	0.21	0.21	0.21	0.21	5

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Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	
Xylenes	15	15	15	15	15	28	12	12	28	28	5
Styrene	0.68	0.68	0.68	0.68	0.68	0.80	0.80	0.80	0.80	0.80	
F1	210	210	210	320	320	210	24	24	270	270	6
F2	150	150	150	260	260	150	130	130	260	260	6
F3	1,300	1,300	1,300	2,500	2,500	300	300	300	1,700	1,700	6
F4	5,600	5,600	5,600	6,600	6,600	2,800	2,800	2,800	3,300	3,300	6
Acenapthene	0.32	0.32	0.32	0.32	0.32	0.38	0.38	0.38	0.38	0.38	
Acenaphthylene	5.0	5.0	5.0	5.0	5.0	6.0	6.0	6.0	6.0	6.0	
Anthracene	0.0046	0.0046	0.0046	0.0046	0.0046	0.0056	0.0056	0.0056	0.0056	0.0056	
Fluoranthene	0.032	0.032	0.032	0.032	0.032	0.039	0.039	0.039	0.039	0.039	
Fluorene	0.29	0.29	0.29	0.29	0.29	0.34	0.34	0.34	0.34	0.34	
Naphthalene	0.016	0.016	0.016	0.016	0.016	0.018	0.018	0.018	0.018	0.018	
Phenanthrene	0.051	0.051	0.051	0.051	0.051	0.061	0.061	0.061	0.061	0.061	
Pyrene	0.034	0.034	0.034	0.034	0.034	0.040	0.040	0.040	0.040	0.040	
Carcinogenic PAHs	IARC<1.0	IARC<1.0	IARC<1.0	IARC<1.0	IARC<1.0	IARC<1.0	5.3; IARC<1.0	5.3; IARC<1.0	8.0; IARC<1.0	8.0; IARC<1.0	7
Benz[a]anthracene	0.070	0.070	0.070	0.070	0.070	0.083	0.083	0.083	0.083	0.083	8
Benzo[b+j]fluoranthene	6.2	6.2	-	-	-	6.2	6.2	-	-	-	8
Benzo[k]fluoranthene	6.2	6.2	-	-	-	6.2	6.2	-	-	-	8
Benzo[g,h,i]perylene	-	-	-	-	-	-	-	-	-	-	
Benzo[a]pyrene	0.60	0.60	0.70	0.70	0.70	0.60	0.60	0.77	0.77	0.77	8
Chrysene	6.2	6.2	-	-	-	6.2	6.2	-	-	-	8
Dibenz[a,h]anthracene	7.4	7.4	7.4	7.4	7.4	8.4	8.4	8.4	8.4	8.4	8
Indeno[1,2,3-c,d]pyrene	-	-	-	-	-	-	-	-	-	-	
Halogenated Aliphatics											
Vinyl chloride	0.014	0.0083	0.0083	0.014	0.014	0.020	0.00034	0.00034	0.0043	0.0043	
1,1-Dichloroethene	0.15	0.15	0.15	0.15	0.15	0.24	0.021	0.021	0.24	0.24	
Trichloroethene (Trichloroethylene, TCE)	0.054	0.054	0.054	0.054	0.054	0.081	0.012	0.012	0.081	0.081	5, 11
Tetrachloroethene (Tetrachloroethylene, Perchloroethylene, PCE)	0.69	0.69	0.69	0.69	0.69	0.77	0.16	0.16	0.77	0.77	
1,2-Dichloroethane	0.025	0.0062	0.025	0.025	0.025	0.041	0.0027	0.0027	0.033	0.033	
Dichloromethane (Methylene chloride)	0.10	0.052	0.10	0.10	0.10	0.095	0.048	0.095	0.095	0.095	
Trichloromethane (Chloroform)	0.0029	0.0029	0.0029	0.0029	0.0029	0.0030	0.0010	0.0010	0.0030	0.0030	
Tetrachloromethane (Carbon tetrachloride)	0.059	0.013	0.013	0.059	0.059	0.062	0.00056	0.00056	0.0068	0.0068	

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Soil Type	Fine					Coarse					Notes
Land Use	Natural Area	Agricultural	Residential/ Parkland	Commercial	Industrial	Natural Area	Agricultural	Residential/ Parkland	Commercial	Industrial	
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	
Dibromochloromethane	0.91	0.12	0.91	0.91	0.91	1.5	0.12	0.27	1.5	1.5	
Chlorinated Aromatics											
Chlorobenzene	0.61	0.39	0.39	0.61	0.61	1.1	0.018	0.018	0.22	0.22	12
1,2-Dichlorobenzene	0.097	0.097	0.097	0.097	0.097	0.18	0.18	0.18	0.18	0.18	12
1,4-Dichlorobenzene	0.051	0.051	0.051	0.051	0.051	0.098	0.098	0.098	0.098	0.098	
1,2,3-Trichlorobenzene	0.26	0.26	0.26	0.26	0.26	0.31	0.26	0.26	0.31	0.31	
1,2,4-Trichlorobenzene	0.78	0.78	0.78	0.78	0.78	0.93	0.23	0.23	0.93	0.93	
1,3,5-Trichlorobenzene	1.9	1.9	1.9	1.9	1.9	3.6	0.13	0.13	1.3	1.3	
1,2,3,4-Tetrachlorobenzene	0.042	0.042	0.042	0.042	0.042	0.050	0.050	0.050	0.050	0.050	
1,2,3,5-Tetrachlorobenzene	0.37	0.37	0.37	0.37	0.37	0.70	0.10	0.10	0.70	0.70	
1,2,4,5-Tetrachlorobenzene	0.19	0.19	0.19	0.19	0.19	0.37	0.052	0.052	0.37	0.37	
Pentachlorobenzene	3.7	3.7	3.7	3.7	3.7	4.5	4.5	4.5	4.5	4.5	
Hexachlorobenzene	3.6	0.80	3.6	3.6	3.6	7.0	0.50	0.50	6.0	6.0	
2,4-Dichlorophenol	0.0029	0.0029	0.0029	0.0029	0.0029	0.0034	0.0034	0.0034	0.0034	0.0034	
2,4,6-Trichlorophenol	0.19	0.19	0.19	0.19	0.19	0.37	0.37	0.37	0.37	0.37	
2,3,4,6-Tetrachlorophenol	0.039	0.039	0.039	0.039	0.039	0.047	0.047	0.047	0.047	0.047	
Pentachlorophenol	0.024	0.024	0.024	0.024	0.024	0.029	0.029	0.029	0.029	0.029	5
Dioxins & Furans	0.00025	0.000004	0.000004	0.000004	0.000004	0.00025	0.000004	0.000004	0.000004	0.000004	9
PCBs	1.3	1.3	22	33	33	1.3	1.3	22	33	33	5
Pesticides											
Aldicarb	0.041	0.012	0.041	0.041	0.041	0.065	0.012	0.065	0.065	0.065	12
Aldrin	5.9	3.4	3.4	5.1	5.9	7.4	3.4	3.4	5.1	7.4	
Atrazine and metabolites	0.0088	0.0088	0.0088	0.0088	0.0088	0.010	0.010	0.010	0.010	0.010	
Azniphos-methyl	0.41	0.41	0.41	0.41	0.41	0.75	0.75	0.75	0.75	0.75	
Bendiocarb	0.14	0.14	0.14	0.14	0.14	0.21	0.21	0.21	0.21	0.21	
Bromoxynil	0.044	0.044	0.044	0.044	0.044	0.052	0.052	0.052	0.052	0.052	13
Carbaryl	1.9	1.9	1.9	1.9	1.9	3.6	3.6	3.6	3.6	3.6	12
Carbofuran	0.68	0.082	0.68	0.68	0.68	1.2	0.089	1.2	1.2	1.2	12
Chlorothalonil	0.0084	0.0084	0.0084	0.0084	0.0084	0.010	0.010	0.010	0.010	0.010	
Chlorpyrifos	49	3.2	49	49	49	95	3.8	95	95	95	12
Cyanazine	0.12	0.029	0.12	0.12	0.12	0.21	0.032	0.21	0.21	0.21	12, 13
2,4-D	0.43	0.10	0.43	0.43	0.43	0.67	0.10	0.67	0.67	0.67	12

Table 1. Alberta Tier 1 Soil Remediation Guidelines

Soil Type	Fine					Coarse					Notes
Land Use	Natural Area	Agricultural	Residential/ Parkland	Commercial	Industrial	Natural Area	Agricultural	Residential/ Parkland	Commercial	Industrial	
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	
DDT	0.015	0.015	0.015	0.015	0.015	0.018	0.018	0.018	0.018	0.018	5
Diazinon	2.2	2.2	2.2	2.2	2.2	4.2	4.2	4.2	4.2	4.2	
Dicamba	0.50	0.12	0.50	0.50	0.50	0.79	0.12	0.79	0.79	0.79	12,13
Dichlofop-methyl	2.0	0.059	2.0	2.0	2.0	2.4	0.071	2.4	2.4	2.4	
Dieldrin	0.011	0.011	0.011	0.011	0.011	0.014	0.014	0.014	0.014	0.014	
Dimethoate	0.0058	0.0028	0.0058	0.0058	0.0058	0.0055	0.0027	0.0055	0.0055	0.0055	
Dinoseb	2.8	1.1	2.8	2.8	2.8	5.5	1.3	5.5	5.5	5.5	12
Diquat	11	11	11	11	11	21	21	21	21	21	
Diuron	1.9	1.9	1.9	1.9	1.9	3.5	3.5	3.5	3.5	3.5	
Endosulfan	0.0085	0.0085	0.0085	0.0085	0.0085	0.010	0.010	0.010	0.010	0.010	
Endrin	0.0075	0.0075	0.0075	0.0075	0.0075	0.0090	0.0090	0.0090	0.0090	0.0090	
Glyphosate	0.054	0.054	0.054	0.054	0.054	0.049	0.049	0.049	0.049	0.049	
Heptachlor epoxide	0.039	0.039	0.039	0.039	0.039	0.076	0.010	0.010	0.076	0.076	12
Lindane	0.31	0.11	0.31	0.31	0.31	0.60	0.13	0.60	0.60	0.60	12
Linuron	0.051	0.051	0.051	0.051	0.051	0.059	0.059	0.059	0.059	0.059	13
Malathion	0.82	0.82	0.82	0.82	0.82	1.3	1.3	1.3	1.3	1.3	12
MCPA	0.020	0.020	0.020	0.020	0.020	0.032	0.025	0.032	0.032	0.032	12,13
Methoxychlor	0.046	0.046	0.046	0.046	0.046	0.056	0.056	0.056	0.056	0.056	
Metolachlor	0.048	0.048	0.048	0.048	0.048	0.055	0.055	0.055	0.055	0.055	
Metribuzin	0.024	0.012	0.024	0.024	0.024	0.028	0.014	0.028	0.028	0.028	
Paraquat (as dichloride)	1.1	1.1	1.1	1.1	1.1	2.2	2.2	2.2	2.2	2.2	
Parathion	7.2	7.2	7.2	7.2	7.2	14	14	14	14	14	12
Phorate	0.075	0.075	0.075	0.075	0.075	0.14	0.14	0.14	0.14	0.14	
Picloram	0.024	0.024	0.024	0.024	0.024	0.022	0.022	0.022	0.022	0.022	
Simazine	0.033	0.033	0.033	0.033	0.033	0.038	0.038	0.038	0.038	0.038	13
Tebuthiuron	2.5	0.12	2.5	2.5	2.5	3.7	0.11	3.7	3.7	3.7	12,13
Terbufos	0.080	0.080	0.080	0.080	0.080	0.15	0.15	0.15	0.15	0.15	
Toxaphene	3.3	3.3	3.3	3.3	3.3	6.3	4.8	4.8	6.3	6.3	12
Triallate	0.0077	0.0077	0.0077	0.0077	0.0077	0.0092	0.0092	0.0092	0.0092	0.0092	
Trifluarin	0.038	0.038	0.038	0.038	0.038	0.045	0.045	0.045	0.045	0.045	
Other Organics											
Aniline	0.36	0.36	0.36	0.36	0.36	0.60	0.60	0.60	0.60	0.60	12
Bis(2-ethyl-hexyl)phthalate	34	34	34	34	34	41	41	41	41	41	

Table 1. Alberta Tier 1 Soil Remediation Guidelines

Soil Type	Fine					Coarse					Notes
Land Use	Natural Area	Agricultural	Residential/ Parkland	Commercial	Industrial	Natural Area	Agricultural	Residential/ Parkland	Commercial	Industrial	
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	
Dibutyl phthalate	0.54	0.54	0.54	0.54	0.54	0.65	0.65	0.65	0.65	0.65	
Dichlorobenzidine	4.2	4.2	4.2	4.2	4.2	8.1	8.1	8.1	8.1	8.1	
Diisopropanolamine	14	14	14	14	14	17	17	17	17	17	5
Ethylene glycol	60	60	60	60	60	62	62	62	62	62	5
Hexachlorobutadiene	0.026	0.026	0.026	0.026	0.026	0.031	0.0067	0.0067	0.031	0.031	
Methylmethacrylate	1.3	1.3	1.3	1.3	1.3	1.8	0.10	0.10	1.3	1.3	
MTBE	0.044	0.044	0.044	0.044	0.044	0.062	0.046	0.046	0.062	0.062	
Nonylphenol + ethoxylates	2.7	2.7	2.7	2.7	2.7	3.3	3.3	3.3	3.3	3.3	5
Phenol	0.0028	0.0014	0.0028	0.0028	0.0028	0.0024	0.0012	0.0024	0.0024	0.0024	5
Sulfolane	0.18	0.18	0.18	0.18	0.18	0.21	0.18	0.21	0.21	0.21	5

Soil Type	Fine					Coarse					Notes
Land Use	Natural Area	Agricultural	Residential/ Parkland	Commercial	Industrial	Natural Area	Agricultural	Residential/ Parkland	Commercial	Industrial	
Unit	(Bq/g)	(Bq/g)	(Bq/g)	(Bq/g)	(Bq/g)	(Bq/g)	(Bq/g)	(Bq/g)	(Bq/g)	(Bq/g)	
Radionuclides											
Uranium-238 Series (all progeny)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	10
Uranium-238 (^{238}U, ^{234}Th, ^{234}mPa, ^{234}U)	10	10	10	10	10	10	10	10	10	10	10
Thorium-230	10	10	10	10	10	10	10	10	10	10	10
Radium-226 (in equilibrium with its progeny)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	10
Lead-210 (in equilibrium with ^{210}Bi and ^{210}Po)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	10
Thorium-232 Series (all progeny)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	10
Thorium-232	10	10	10	10	10	10	10	10	10	10	10
Radium-228 (in equilibrium with ^{228}Ac)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	10
Thorium-228 (in equilibrium with its progeny)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	10
Potassium-40	17	17	17	17	17	17	17	17	17	17	10

Table 1. Alberta Tier 1 Soil Remediation Guidelines

Notes:

Guideline values calculated for this document using latest available CCME protocols except where noted.

1. *Value adopted from AEP (1994) and/or CCME 1991*
2. *Value adopted from CCME (1999)*
3. *For more information see Guidelines for the Remediation and Disposal of Sulphur Contaminated Solid Wastes (AEP, 1996)*
4. *For more information see Soil Quality Guidelines for Barite: Environmental Health and Human Health (AENV, 2004)*
5. *Ecological direct contact values from CCME (1999), other values calculated in this document*
6. *Ecological direct contact values from CCME (2007), other values calculated in this document*
7. *Carcinogenic PAH concentrations in coarse textured soil under all land uses except natural areas must meet both the Human Direct Contact guideline (5.3 mg/kg or 8.0 mg/kg as B[a]P TPE) and the Index of Additive Cancer Risk (IACR) <1 guideline. Individual PAH compounds must also meet guidelines for ecological receptors where specified in Table 1 with footnote 8.*

B[a]P TPE (Total Potency Equivalents) are calculated by multiplying the soil concentration of individual carcinogenic PAHs by a standardized Benzo[a]pyrene Potency Equivalence Factor (PEF) to produce a Benzo[a]pyrene relative potency concentration, and by subsequently summing the relative potency concentrations for the entire PAH mixture. B[a]P PEFs are order of magnitude estimates of carcinogenic potential and are based on the estimates of carcinogenic potential and are based on the World Health Organization (1999) scheme, as follows:

Carcinogenic PAH Compound	PEF
Benz[a]anthracene	0.1
Benzo(b+j)fluoranthene	0.1
Benzo[k]fluoranthene	0.1
Benzo[ghi]perylene	0.01
Benzo[a]pyrene	1
Chrysene	0.01
Dibenz[a,h]anthracene	1
Indeno[1,2,3-c,d]pyrene	0.1

The IACR is calculated by dividing the soil concentration of each carcinogenic PAH by its Protection of Domestic Use Aquifer guideline value to calculate a hazard index for each PAH and subsequently summing the hazard indexes for the entire PAH mixture, as follows:

Fine Soil:

$$IACR = \frac{[Benz(a)anthracene]}{1.6\ mg \cdot kg^{-1}} + \frac{[Benzo(b+j)fluoranthene]}{0.74\ mg \cdot kg^{-1}} + \frac{[Benzo(k)fluoranthene]}{0.16\ mg \cdot kg^{-1}} + \frac{[Benzo(g,h,i)perylene]}{32\ mg \cdot kg^{-1}} + \frac{[Benzo(a)pyrene]}{1.7\ mg \cdot kg^{-1}} + \frac{[Chrysene]}{10\ mg \cdot kg^{-1}} + \frac{[Dibenz(a,h)anthracene]}{1.1\ mg \cdot kg^{-1}} + \frac{[Indeno(1,2,3-c,d)pyrene]}{13\ mg \cdot kg^{-1}}$$

Coarse Soil:

$$IACR = \frac{[Benz(a)anthracene]}{3.1\ mg \cdot kg^{-1}} + \frac{[Benzo(b+j)fluoranthene]}{1.4\ mg \cdot kg^{-1}} + \frac{[Benzo(k)fluoranthene]}{0.31\ mg \cdot kg^{-1}} + \frac{[Benzo(g,h,i)perylene]}{63\ mg \cdot kg^{-1}} + \frac{[Benzo(a)pyrene]}{3.4\ mg \cdot kg^{-1}} + \frac{[Chrysene]}{19\ mg \cdot kg^{-1}} + \frac{[Dibenz(a,h)anthracene]}{2.1\ mg \cdot kg^{-1}} + \frac{[Indeno(1,2,3-c,d)pyrene]}{24\ mg \cdot kg^{-1}}$$

Table 1. Alberta Tier 1 Soil Remediation Guidelines

8. For ecological receptors only

9. Expressed as toxic equivalents (TEQs) based on 2,3,7,8-TCDD (See CCME, 1999 and updates)

10. When two or more radionuclides are found, the following relationship should be satisfied:

$$\frac{[\text{Radionuclide}]_1}{\text{Guideline}_1} + \frac{[\text{Radionuclide}]_2}{\text{Guideline}_2} + \ldots \frac{[\text{Radionuclide}]_i}{\text{Guideline}_i} \leq 1$$

For more information see Canadian Guidelines for the Management of Naturally Occurring Radioactive Materials (NORM) (Health Canada, 2000)

11. If trichloroethene is found in soil, its degradation product vinyl chloride must also be measured and compared to guideline values

12. Guideline for protection of aquatic life is below detection limit and has not been included in the Tier 1 derivation.

Groundwater monitoring is required for all land uses if the Tier 1 guideline is exceeded.

13. Guideline for protection of irrigation water is below detection limit and has not been included in the Tier 1 derivation.

Groundwater monitoring is required for agricultural land use if the Tier 1 guideline is exceeded.

Table 2. Alberta Tier 1 Groundwater Remediation Guidelines

Soil Type	Fine				Coarse				Notes
Land Use	Natural Area	Agricultural	Residential/ Parkland	Commercial/ Industrial	Natural Area	Agricultural	Residential/ Parkland	Commercial/ Industrial	
Unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	
General and Inorganic Parameters									
pH	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	
Ammonia	see note 1	see note 1	see note 1	see note 1	see note 1	see note 1	see note 1	see note 1	1
Chloride	230	100	230	230	230	100	230	230	
Cyanide	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	
Fluoride	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	
Nitrate	13	13	13	13	13	13	13	13	
Nitrate + Nitrite (as nitrogen)	-	100	-	-	-	100	-	-	
Nitrite (as nitrogen)	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	
Sodium	200	200	200	200	200	200	200	200	
Sulphate	500	500	500	500	500	500	500	500	
Sulphide (as H_2S)	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	
Total Dissolved Solids (TDS)	500	500	500	500	500	500	500	500	
Metals									
Aluminum	see note 1	see note 2	see note 1	see note 1	see note 1	see note 2	see note 1	see note 1	1
Antimony	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	
Arsenic	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	
Barium	1	1	1	1	1	1	1	1	
Boron	5	0.5	5	5	5	0.5	5	5	
Bromate	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	
Cadmium	see note 2	see note 2	see note 2	see note 2	see note 2	see note 2	see note 2	see note 2	2
Chromium	see note 2	see note 2	see note 2	see note 2	see note 2	see note 2	see note 2	see note 2	2
Copper	see note 2	see note 2	see note 2	see note 2	see note 2	see note 2	see note 2	see note 2	2
Iron	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Lead	see note 2	see note 2	see note 2	see note 2	see note 2	see note 2	see note 2	see note 2	2
Manganese	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	
Mercury	see note 2	see note 2	see note 2	see note 2	see note 2	see note 2	see note 2	see note 2	2
Nickel	see note 1	see note 2	see note 1	see note 1	see note 1	see note 2	see note 1	see note 1	1,2
Selenium	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	
Silver	see note 1	see note 2	see note 1	see note 1	see note 1	see note 2	see note 1	see note 1	1,2
Uranium	0.02	0.01	0.02	0.02	0.02	0.01	0.02	0.02	
Zinc	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	

Table 2. Alberta Tier 1 Groundwater Remediation Guidelines

Soil Type	Fine				Coarse				Notes
Land Use	Natural Area	Agricultural	Residential/ Parkland	Commercial/ Industrial	Natural Area	Agricultural	Residential/ Parkland	Commercial/ Industrial	
Unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	
Hydrocarbons									
Benzene	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	
Toluene	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	
Ethylbenzene	0.0024	0.0024	0.0024	0.0024	0.0024	0.0024	0.0024	0.0024	
Xylenes	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Styrene	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	
F1	2.2	2.2	2.2	2.2	2.2	0.81	0.81	2.2	
F2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	
Acenapthene	0.0058	0.0058	0.0058	0.0058	0.0058	0.0058	0.0058	0.0058	
Acenaphthylene	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	
Anthracene	0.000012	0.000012	0.000012	0.000012	0.000012	0.000012	0.000012	0.000012	
Fluoranthene	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	
Fluorene	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	
Naphthalene	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	
Phenanthrene	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	
Pyrene	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	
Carcinogenic PAHs (as B(a)P TPE)	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	3
Benz[a]anthracene	0.000018	0.000018	0.000018	0.000018	0.000018	0.000018	0.000018	0.000018	4
Benzo[b+j]fluoranthene	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	4
Benzo[k]fluoranthene	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	4
Benzo[g,h,i]perylene	0.00021	0.00021	0.00021	0.00021	0.00017	0.00017	0.00017	0.00017	4
Benzo[a]pyrene	0.000017	0.000017	0.000017	0.000017	0.000015	0.000015	0.000015	0.000015	4
Chrysene	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	4
Dibenz[a,h]anthracene	0.00028	0.00028	0.00028	0.00028	0.00026	0.00026	0.00026	0.00026	4
Indeno[1,2,3-c,d]pyrene	0.00023	0.00023	0.00023	0.00023	0.00021	0.00021	0.00021	0.00021	4
Halogenated Aliphatics									
Vinyl chloride	0.002	0.002	0.002	0.002	0.002	0.0011	0.0011	0.002	
1,1-Dichloroethene	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	
Trichloroethene (Trichloroethylene, TCE)	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	5
Tetrachloroethene (Tetrachloroethylene, Perchloroethylene, PCE)	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	
1,2-Dichloroethane	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	

Table 2. Alberta Tier 1 Groundwater Remediation Guidelines

Soil Type	Fine				Coarse				Notes
Land Use	Natural Area	Agricultural	Residential/ Parkland	Commercial/ Industrial	Natural Area	Agricultural	Residential/ Parkland	Commercial/ Industrial	
Unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	
Dichloromethane (Methylene chloride)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	
Trichloromethane (Chloroform)	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	
Tetrachloromethane (Carbon tetrachloride)	0.005	0.005	0.005	0.005	0.005	0.00056	0.00056	0.005	
Dibromochloromethane	0.19	0.1	0.19	0.19	0.19	0.1	0.19	0.19	
Chlorinated Aromatics									
Chlorobenzene	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	
1,2-Dichlorobenzene	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	
1,4-Dichlorobenzene	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	
1,2,3-Trichlorobenzene	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	
1,2,4-Trichlorobenzene	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	
1,3,5-Trichlorobenzene	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	
1,2,3,4-Tetrachlorobenzene	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	
1,2,3,5-Tetrachlorobenzene	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	
1,2,4,5-Tetrachlorobenzene	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	
Pentachlorobenzene	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	
Hexachlorobenzene	0.00057	0.00052	0.00057	0.00057	0.00057	0.00052	0.00057	0.00057	
2,4-Dichlorophenol	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	
2,4,6-Trichlorophenol	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	
2,3,4,6-Tetrachlorophenol	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	
Pentachlorophenol	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	
Dioxins & Furans	0.000000012	0.000000012	0.000000012	0.000000012	0.000000012	0.000000012	0.000000012	0.000000012	
PCBs	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094	
Pesticides									
Aldicarb	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	
Aldrin and dieldrin	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	
Atrazine and metabolites	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	
Azniphos-methyl	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	
Bendiocarb	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	
Bromoxynil	0.005	0.00033	0.005	0.005	0.005	0.00033	0.005	0.005	
Carbaryl	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	
Carbofuran	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	
Chlorothalonil	0.00018	0.00018	0.00018	0.00018	0.00018	0.00018	0.00018	0.00018	

Table 2. Alberta Tier 1 Groundwater Remediation Guidelines

Soil Type	Fine				Coarse				Notes
Land Use	Natural Area	Agricultural	Residential/ Parkland	Commercial/ Industrial	Natural Area	Agricultural	Residential/ Parkland	Commercial/ Industrial	
Unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	
Chlorpyrifos	0.0000035	0.0000035	0.0000035	0.0000035	0.0000035	0.0000035	0.0000035	0.0000035	
Cyanazine	0.002	0.0005	0.002	0.002	0.002	0.0005	0.002	0.002	
2,4-D	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	
DDT	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	
Diazinon	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	
Dicamba	0.01	0.000006	0.01	0.01	0.01	0.000006	0.01	0.01	
Dichlofop-methyl	0.0061	0.00018	0.0061	0.0061	0.0061	0.00018	0.0061	0.0061	
Dieldrin	0.000056	0.000056	0.000056	0.000056	0.000056	0.000056	0.000056	0.000056	
Dimethoate	0.0062	0.003	0.0062	0.0062	0.0062	0.003	0.0062	0.0062	
Dinoseb	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	
Diquat	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	
Diuron	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	
Endosulfan	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	
Endrin	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	0.000036	
Glyphosate	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	
Heptachlor epoxide	0.0000038	0.0000038	0.0000038	0.0000038	0.0000038	0.0000038	0.0000038	0.0000038	
Lindane	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	
Linuron	0.007	0.000071	0.007	0.007	0.007	0.000071	0.007	0.007	
Malathion	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	
MCPA	0.0026	0.000025	0.0026	0.0026	0.0026	0.000025	0.0026	0.0026	
Methoxychlor	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	
Metolachlor	0.0078	0.0078	0.0078	0.0078	0.0078	0.0078	0.0078	0.0078	
Metribuzin	0.001	0.0005	0.001	0.001	0.001	0.0005	0.001	0.001	
Paraquat (as dichloride)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	
Parathion	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	
Phorate	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	
Picloram	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	
Simazine	0.01	0.0005	0.01	0.01	0.01	0.0005	0.01	0.01	
Tebuthiuron	0.0016	0.00027	0.0016	0.0016	0.0016	0.00027	0.0016	0.0016	
Terbufos	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	
Toxaphene	0.0000002	0.0000002	0.0000002	0.0000002	0.0000002	0.0000002	0.0000002	0.0000002	
Triallate	0.00024	0.00024	0.00024	0.00024	0.00024	0.00024	0.00024	0.00024	

Table 2. Alberta Tier 1 Groundwater Remediation Guidelines

Soil Type	Fine				Coarse				Notes
Land Use	Natural Area	Agricultural	Residential/ Parkland	Commercial/ Industrial	Natural Area	Agricultural	Residential/ Parkland	Commercial/ Industrial	
Unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	
Trifluarin	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	
Other Organics									
Aniline	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	
Bis(2-ethyl-hexyl)phthalate	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	
Dibutyl phthalate	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	
Dichlorobenzidine	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	
Diisopropanolamine	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	
Ethylene glycol	31	31	31	31	31	31	31	31	
Hexachlorobutadiene	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	
Methylmethacrylate	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	
MTBE	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	
Nitrilotriacetic acid	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	
Nonylphenol + ethoxylates	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	
Phenol	0.004	0.002	0.004	0.004	0.004	0.002	0.004	0.004	
Sulfolane	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	
Trihalomethanes - total (THMs)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	

Soil Type	Fine				Coarse				Notes
Land Use	Natural Area	Agricultural	Residential/ Parkland	Commercial/ Industrial	Natural Area	Agricultural	Residential/ Parkland	Commercial/ Industrial	
Unit	(Bq/L)	(Bq/L)	(Bq/L)	(Bq/L)	(Bq/L)	(Bq/L)	(Bq/L)	(Bq/L)	
Naturally Occurring Radionuclides									
Beryllium-7	4000	4000	4000	4000	4000	4000	4000	4000	6
Bismuth-210	70	70	70	70	70	70	70	70	6
Lead-210	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	6
Polonium-210	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	6
Radium -224	2	2	2	2	2	2	2	2	6
Radium-226	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	6
Radium-228	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	6
Thorium-228	2	2	2	2	2	2	2	2	6
Thorium-230	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	6
Thorium-232	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	6

Table 2. Alberta Tier 1 Groundwater Remediation Guidelines

Soil Type	Fine				Coarse				Notes
Land Use	Natural Area	Agricultural	Residential/ Parkland	Commercial/ Industrial	Natural Area	Agricultural	Residential/ Parkland	Commercial/ Industrial	
Unit	(Bq/L)	(Bq/L)	(Bq/L)	(Bq/L)	(Bq/L)	(Bq/L)	(Bq/L)	(Bq/L)	
Thorium-234	20	20	20	20	20	20	20	20	6
Uranium-234	4	4	4	4	4	4	4	4	6
Uranium-235	4	4	4	4	4	4	4	4	6
Uranium-238	4	4	4	4	4	4	4	4	6
Other Radionuclides									
Americium-241	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	6
Antimony-122	50	50	50	50	50	50	50	50	6
Antimony-124	40	40	40	40	40	40	40	40	6
Antimony-125	100	100	100	100	100	100	100	100	6
Barium-140	40	40	40	40	40	40	40	40	6
Bromine-82	300	300	300	300	300	300	300	300	6
Calcium-45	200	200	200	200	200	200	200	200	6
Calcium-47	60	60	60	60	60	60	60	60	6
Carbon-14a	200	200	200	200	200	200	200	200	6
Cerium-141	100	100	100	100	100	100	100	100	6
Cerium-144	20	20	20	20	20	20	20	20	6
Cesium-131	2000	2000	2000	2000	2000	2000	2000	2000	6
Cesium-136	50	50	50	50	50	50	50	50	6
Chromium-51	3000	3000	3000	3000	3000	3000	3000	3000	6
Cobalt-57	40	40	40	40	40	40	40	40	6
Cobalt-58	20	20	20	20	20	20	20	20	6
Cobalt-60	2	2	2	2	2	2	2	2	6
Gallium-67	500	500	500	500	500	500	500	500	6
Gold-198	90	90	90	90	90	90	90	90	6
Indium-111	400	400	400	400	400	400	400	400	6
Iodine-129	1	1	1	1	1	1	1	1	6
Iron-55	300	300	300	300	300	300	300	300	6
Iron-59	40	40	40	40	40	40	40	40	6
Manganese-54	200	200	200	200	200	200	200	200	6
Mercury-197	400	400	400	400	400	400	400	400	6
Mercury-203	80	80	80	80	80	80	80	80	6
Neptunium-239	100	100	100	100	100	100	100	100	6

Table 2. Alberta Tier 1 Groundwater Remediation Guidelines

Soil Type	Fine				Coarse				Notes
Land Use	Natural Area	Agricultural	Residential/ Parkland	Commercial/ Industrial	Natural Area	Agricultural	Residential/ Parkland	Commercial/ Industrial	
Unit	(Bq/L)	(Bq/L)	(Bq/L)	(Bq/L)	(Bq/L)	(Bq/L)	(Bq/L)	(Bq/L)	
Niobium-95	200	200	200	200	200	200	200	200	6
Phosphorus-32	50	50	50	50	50	50	50	50	6
Plutonium-238	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	6
Plutonium-239	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	6
Plutonium-240	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	6
Plutonium-241	10	10	10	10	10	10	10	10	6
Rhodium-105	300	300	300	300	300	300	300	300	6
Rubidium-81	3000	3000	3000	3000	3000	3000	3000	3000	6
Rubidium-86	50	50	50	50	50	50	50	50	6
Ruthenium-103	100	100	100	100	100	100	100	100	6
Ruthenium-106	10	10	10	10	10	10	10	10	6
Selenium-75	70	70	70	70	70	70	70	70	6
Silver-108m	70	70	70	70	70	70	70	70	6
Silver-110m	50	50	50	50	50	50	50	50	6
Silver-111	70	70	70	70	70	70	70	70	6
Sodium-22	50	50	50	50	50	50	50	50	6
Strontium-85	300	300	300	300	300	300	300	300	6
Strontium-89	40	40	40	40	40	40	40	40	6
Sulphur-35	500	500	500	500	500	500	500	500	6
Technetium-99	200	200	200	200	200	200	200	200	6
Technetium-99m	7000	7000	7000	7000	7000	7000	7000	7000	6
Tellurium-129m	40	40	40	40	40	40	40	40	6
Tellurium-131m	40	40	40	40	40	40	40	40	6
Tellurium-132	40	40	40	40	40	40	40	40	6
Thallium-201	2000	2000	2000	2000	2000	2000	2000	2000	6
Ytterbium-169	100	100	100	100	100	100	100	100	6
Yttrium-90	30	30	30	30	30	30	30	30	6
Yttrium-91	30	30	30	30	30	30	30	30	6
Zinc-65	40	40	40	40	40	40	40	40	6
Zirconium-95	100	100	100	100	100	100	100	100	6

Table 2. Alberta Tier 1 Groundwater Remediation Guidelines

Notes:

1. *See Surface Water Quality Guidelines for Use in Alberta (AENV, 1999) for further guidance on aquatic life pathway.*
2. *Tier 1 guideline = lowest of aquatic life guideline and all other guidelines (See Appendix B).*
3. *B[a]P TPE (Total Potency Equivalents) are calculated by multiplying the groundwater concentration of individual carcinogenic PAHs by a standardized Benzo[a]pyrene Potency Equivalence Factor (PEF) to produce a Benzo[a]pyrene relative potency concentration, and by subsequently summing the relative potency concentrations for the entire PAH mixture. B[a]P PEFs are order of magnitude estimates of carcinogenic potential and are based on the estimates of carcinogenic potential and are based on the World Health Organization (1999) scheme, as follows:*

Carcinogenic PAH Compound	PEF
Benz[a]anthracene	0.1
Benzo(b+j)fluoranthene	0.1
Benzo[k]fluoranthene	0.1
Benzo[ghi]perylene	0.01
Benzo[a]pyrene	1
Chrysene	0.01
Dibenz[a,h]anthracene	1
Indeno[1,2,3-c,d]pyrene	0.1

4. *For ecological receptors only.*
5. *If trichloroethene is found in groundwater, its degradation product vinyl chloride must also be measured and compared to guideline values.*
6. *When two or more radionuclides are found, the following relationship should be satisfied:*

$$\frac{[\text{Radionuclide}]_1}{\text{Guideline}_1} + \frac{[\text{Radionuclide}]_2}{\text{Guideline}_2} + \ldots \frac{[\text{Radionuclide}]_i}{\text{Guideline}_i} \leq 1$$

NGR = no guideline required - values for all exposure pathways that could be calculated are above compound solubility.

Table 3. Alberta Tier 1 Subsoil Remediation Guidelines (BTEX and PHCs Only)

Soil Type	Fine					Coarse					Notes
Land Use	Natural Area	Agricultural	Residential/ Parkland	Commercial	Industrial	Natural Area	Agricultural	Residential/ Parkland	Commercial	Industrial	
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	
Benzene	0.046	0.046	0.046	0.046	0.046	0.078	0.078	0.078	0.078	0.078	2
Toluene	0.52	0.52	0.52	0.52	0.52	0.49	0.49	0.49	0.49	0.49	2
Ethylbenzene	0.11	0.11	0.11	0.11	0.11	0.21	0.21	0.21	0.21	0.21	2
Xylenes	15	15	15	15	15	28	16	16	28	28	2
F1	420	420	420	640	640	420	30	30	440	440	1, 3
F2	300	300	300	520	520	300	160	160	520	520	1, 3
F3	2,600	2,600	2,600	3,500	3,500	600	600	600	2,500	2,500	1, 3
F4	10,000	10,000	10,000	10,000	10,000	5,600	5,600	5,600	6,600	6,600	1, 3

Notes:

Guideline values calculated for this document using latest available CCME protocols except where noted.

1. Ecological direct contact pathway may be eliminated below 3 metres in depth for F1 to F4 only; the next lowest guideline value applies.

2. Ecological direct contact values from CCME (1999), other values calculated in this document

3. All values calculated in this document

Table 4. Alberta Tier 1 Salt Remediation Guidelines

Rating Categories	Good	Fair	Poor	Unsuitable	Commercial/Industrial
Topsoil					
EC[a] (dS/m)	<2[c]	2 to 4	4 to 8	>8	4
SAR[b]	<4	4 to 8	8 to 12	>12[d]	12
Subsoil					
EC[a] (dS/m)	<3	3 to 5	5 to 10	>10	4
SAR[b]	<4	4 to 8	8 to 12	>12	12

Notes:

a. Electrical conductivity

b. Sodium Adsorption Ratio

c. Some plants are sensitive to salts at EC < 2 dS/m (e.g., flax, clover, beans, some wheat varieties, peas, some garden crops).

d. Material characterized by SAR of 12 to 20 may be rated as poor if texture is sandy loam or coarser and saturation % is less than 100.

e. Topsoil: surface A, L, F, H, and O horizons on the control area, or the equivalent surface soil where these horizons are not present.

Subsoil: B and C horizons and the upper portion of the parent material.

FIGURES

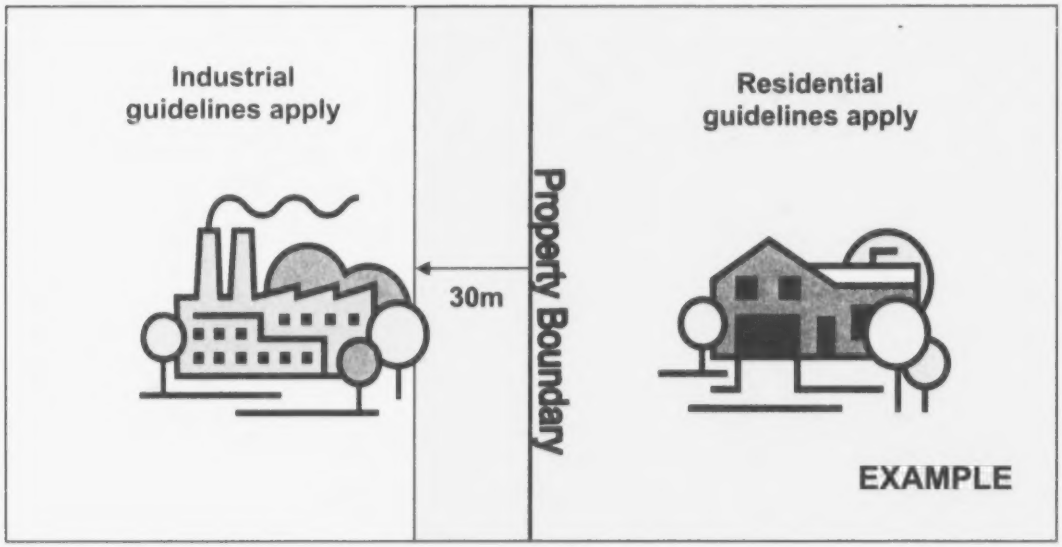

Figure 1: Example of the 30 m buffer zone for the more sensitive land use. The diagram is for illustration purposes and can be applied for any land use scenario where a more sensitive land use is adjacent to a less sensitive land use.

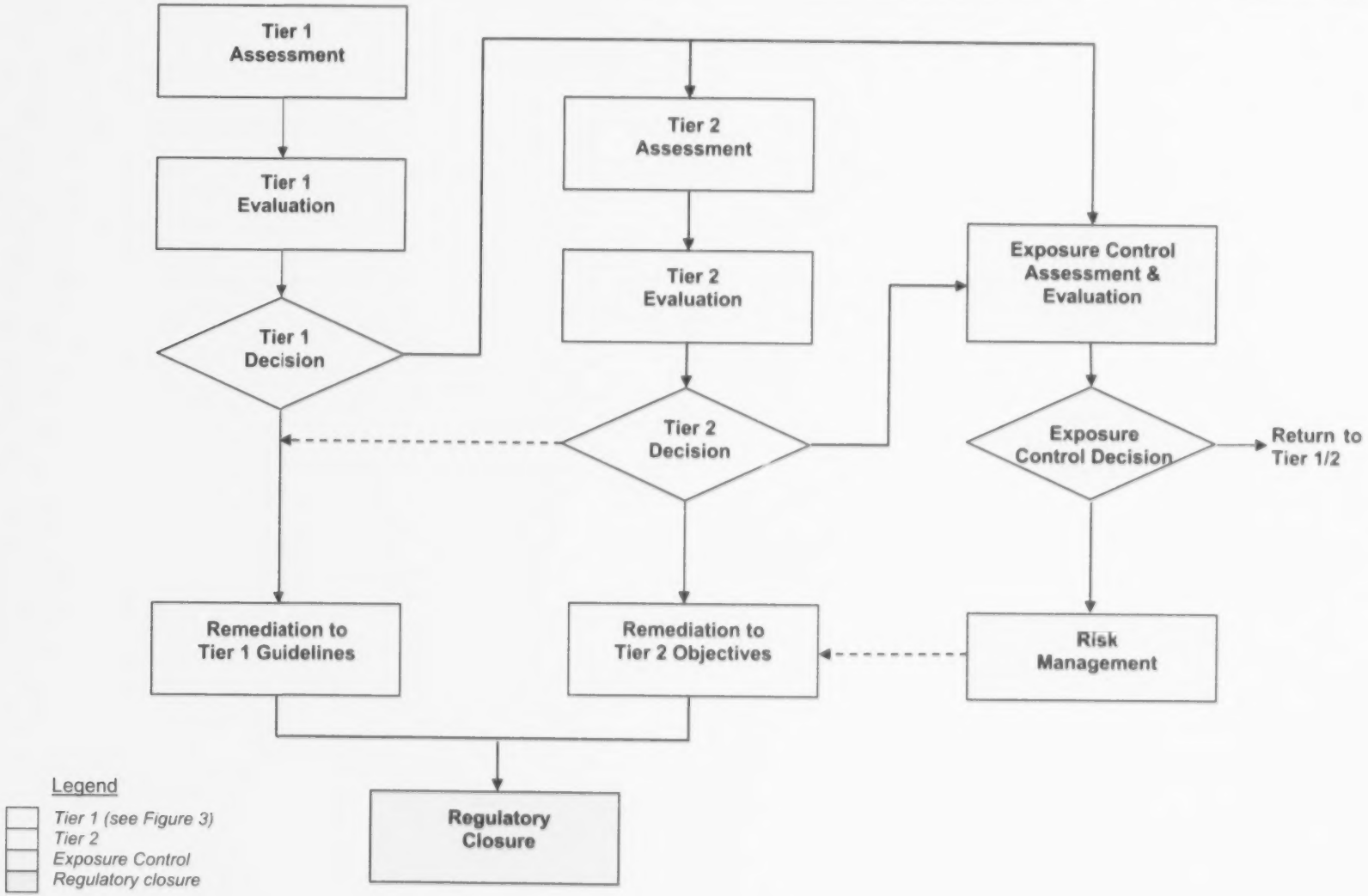

Figure 2: Implementation Framework for Tier 1, Tier 2 and Exposure Control Guidelines

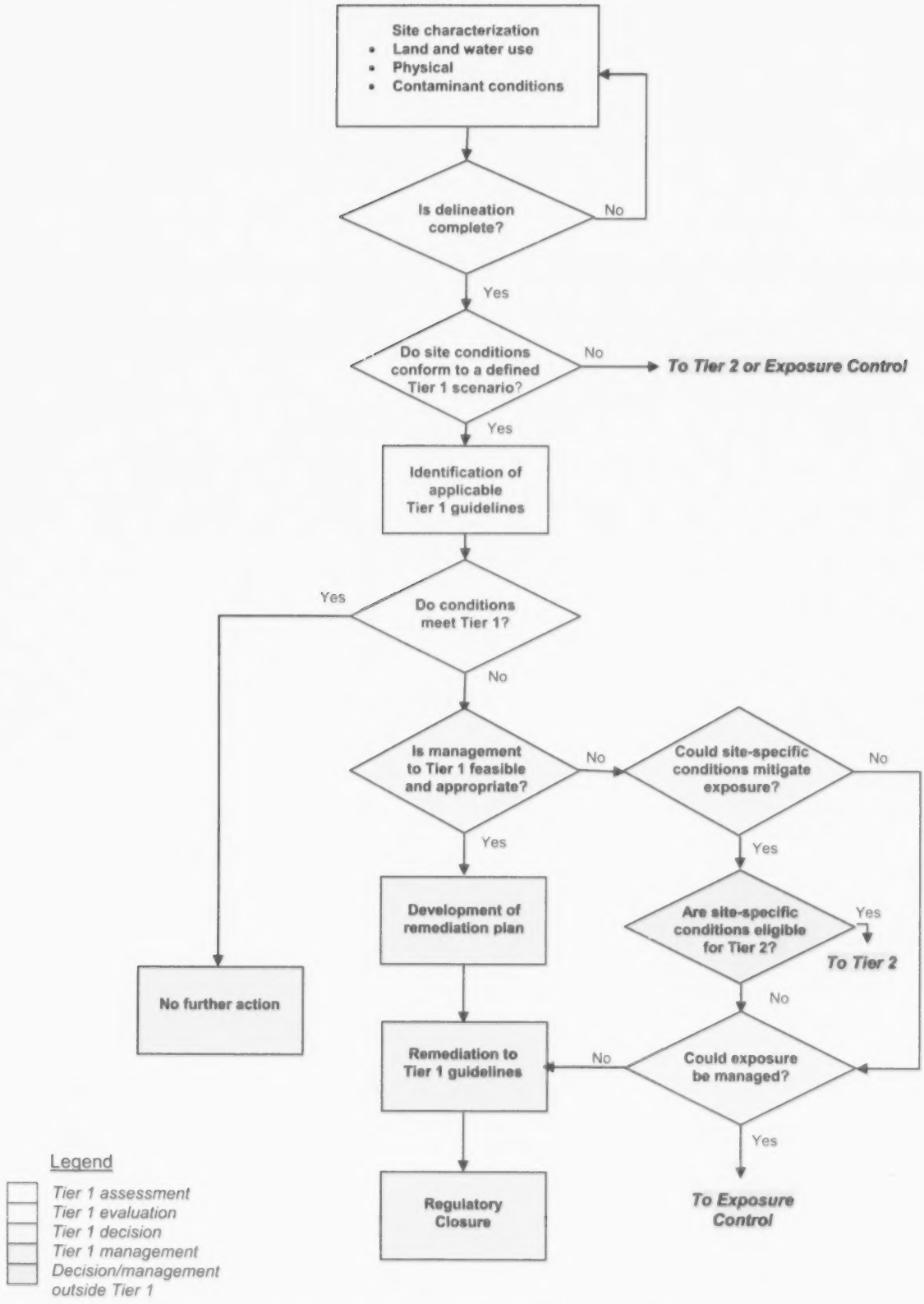

Figure 3: Expanded Flow Diagram – Tier 1

APPENDIX A
SOIL REMEDIATION GUIDELINES
ALL EXPOSURE PATHWAYS

Appendix A consists of ten tables, comprised of surface soil and subsoil tables for each of the land uses. Each table provides the soil remediation guideline for each exposure pathway, where available. **Tier 1 guidelines must be chosen from Tables 1 to 4, not from Appendix A or B.** The only exception occurs when a more sensitive land use borders on, or is less than 30m from, the site of interest. Under this condition guidelines for specific exposure pathways on the more sensitive land use must be evaluated and if they are lower than the Tier 1 guideline, they must be applied to the site of interest (See Section 5.1.2 and Figure 1).

The ten tables are as follows:

- Table A-1. Surface Soil Remediation Guidelines for Natural Area Land Use
- Table A-2. Surface Soil Remediation Guidelines for Agricultural Land Use
- Table A-3. Surface Soil Remediation Guidelines for Residential/Parkland Use
- Table A-4. Surface Soil Remediation Guidelines for Commercial Land Use
- Table A-5. Surface Soil Remediation Guidelines for Industrial Land Use
- Table A-6. Subsoil Remediation Guidelines for Natural Area Land Use
- Table A-7. Subsoil Remediation Guidelines for Agricultural Land Use
- Table A-8. Subsoil Remediation Guidelines for Residential/Parkland Use
- Table A-9. Subsoil Remediation Guidelines for Commercial Land Use
- Table A-10. Subsoil Remediation Guidelines for Industrial Land Use

In some cases, there is a value for the overall guideline, but no values for individual exposure pathways. This situation corresponds to non-risk-based guidelines that have been adopted from previous guideline documents, as explained in the main text.

All exposure pathways are applicable at Tier 1. However, it may be possible to exclude or modify certain pathways at Tier 2. The companion Tier 2 document (AENV, 2008a) should be consulted for further information. The information in the tables in this appendix will assist in determining whether a Tier 2 approach for soil is likely to be useful at a given site.

Table A-1. Surface Soil Remediation Guideline Values for Natural Area Land Use - All Exposure Pathway

This table must <u>not</u> be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Tables 1, 3 and 4. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Receptor	Overall Guideline		Human		Ecological									Other	
Pathway			Protection of Domestic Use Aquifer		Direct Soil Contact		Nutrient Energy Cycling Check	Livestock Soil and Food Ingestion	Wildlife Soil and Food Ingestion	Protection of Freshwater Aquatic Life		Protection of Wildlife Water		Management Limit	
Soil Type	Fine	Coarse	Fine	Coarse	Fine	Coarse	-	-	-	Fine	Coarse	Fine	Coarse	Fine	Coarse
Building Type			-	-	-	-	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
General and Inorganic Parameters															
pH (in 0.01M $CaCl_2$)	6-8.5	6-8.5	-	-	6-8.5	6-8.5	-	-	-	-	-	-	-	-	-
Cyanide (free)	0.9	0.9	-	-	0.9	0.9	-	11	-	-	-	-	-	-	-
Fluoride	200	200	-	-	200	200	-	-	-	-	-	-	-	-	-
Sulphur (elemental)[a]	500	500	-	-	500	500	-	-	-	-	-	-	-	-	-
Metals															
Antimony	20	20	-	-	20	20	-	-	-	-	-	-	-	-	-
Arsenic (inorganic)	17	17	-	-	17	17	-	380	-	-	-	-	-	-	-
Barium	750	750	-	-	750	750	-	-	-	-	-	-	-	-	-
Barite-barium[b]	3,300	3,300	-	-	180,000	180,000	-	3,300	3,300	-	-	-	-	-	-
Beryllium	5	5	-	-	5	5	-	-	-	-	-	-	-	-	-
Boron (hot water soluble)	2	2	-	-	2	2	-	-	-	-	-	-	-	-	-
Cadmium	3.8	3.8	-	-	10	10	54	3.8	-	-	-	-	-	-	-
Chromium (hexavalent)	0.4	0.4	-	-	0.4	0.4	-	-	-	-	-	-	-	-	-
Chromium (total)	64	64	-	-	64	64	52	-	-	-	-	-	-	-	-
Cobalt	20	20	-	-	20	20	-	-	-	-	-	-	-	-	-
Copper	63	63	-	-	63	63	350	300	-	-	-	-	-	-	-
Lead	70	70	-	-	300	300	723	70	-	-	-	-	-	-	-
Mercury (inorganic)	12	12	-	-	12	12	20	-	-	-	-	-	-	-	-
Molybdenum	4	4	-	-	4	4	-	-	-	-	-	-	-	-	-
Nickel	50	50	-	-	50	50	146	355	-	-	-	-	-	-	-
Selenium	1	1	-	-	1	1	-	4.5	-	-	-	-	-	-	-
Silver	20	20	-	-	20	20	-	-	-	-	-	-	-	-	-
Thallium	1	1	-	-	1.4	1.4	-	1.0	-	-	-	-	-	-	-

Table A-1. Surface Soil Remediation Guideline Values for Natural Area Land Use - All Exposure Pathway

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Tables 1, 3 and 4. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Receptor	Overall Guideline		Human		Ecological									Other	
Pathway			Protection of Domestic Use Aquifer		Direct Soil Contact		Nutrient Energy Cycling Check	Livestock Soil and Food Ingestion	Wildlife Soil and Food Ingestion	Protection of Freshwater Aquatic Life		Protection of Wildlife Water		Management Limit	
Soil Type	Fine	Coarse	Fine	Coarse	Fine	Coarse		-	-	Fine	Coarse	Fine	Coarse	Fine	Coarse
Building Type			-	-	-	-	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Tin	5	5	-	-	5	5	-	-	-	-	-	-	-	-	-
Uranium	33	33	-	-	500	500	-	33	-	-	-	-	-	-	-
Vanadium	130	130	-	-	130	130	255	-	-	-	-	-	-	-	-
Zinc	200	200	-	-	200	200	200	640	-	-	-	-	-	-	-
Hydrocarbons															
Benzene	0.046	0.078	0.046	0.078	60	31	-	44	18	73	1.6	15	0.33	-	-
Toluene	0.52	0.49	0.52	0.95	110	75	-	2,500	980	250,000	0.49	NGR	1,000	-	-
Ethylbenzene	0.11	0.21	0.11	0.21	120	55	-	1,600	640	NGR	540	NGR	17,000	-	-
Xylenes	15	28	15	28	65	95	-	6,600	2,600	NGR	250	NGR	16,000	-	-
Styrene	0.68	0.8	110	210	-	-	-	-	-	0.68	0.8	-	-	-	-
F1	210	210	1,100	2,200	210	210	-	27,000	11,000	30,000	1,300	30,000	30,000	800	700
F2	150	150	1,500	2,900	150	150	-	25,000	9,800	30,000	520	30,000	30,000	1,000	1,000
F3	1,300	300	-	-	1,300	300	-	30,000	16,000	-	-	-	-	3,500	2,500
F4	5,600	2,800	-	-	5,600	2,800	-	21,000	8,400	-	-	-	-	10,000	10,000
Acenapthene	0.32	0.38	NGR	NGR	-	-	-	21.5	21.5	0.32	0.38	NGR	NGR	-	-
Acenaphthylene	5.0	6.0	-	-	-	-	-	-	-	5.0	6.0	-	-	-	-
Anthracene	0.0046	0.0056	NGR	NGR	2.5	2.5	-	61.5	61.5	0.0046	0.0056	NGR	NGR	-	-
Fluoranthene	0.032	0.039	NGR	NGR	50	50	-	15.4	15.4	0.032	0.039	NGR	NGR	-	-
Fluorene	0.29	0.34	NGR	NGR	-	-	-	15.4	15.4	0.29	0.34	NGR	NGR	-	-
Naphthalene	0.016	0.018	28	53	-	-	-	8.8	8.8	0.016	0.018	NGR	NGR	-	-
Phenanthrene	0.051	0.061	-	-	-	-	-	43	43	0.051	0.061	NGR	NGR	-	-
Pyrene	0.034	0.040	NGR	NGR	-	-	-	7.7	7.7	0.034	0.040	NGR	NGR	-	-
Carcinogenic PAHs	IARC<1.0 [c]	IARC<1.0 [c]	IARC<1.0 [c]	IARC<1.0 [c]	-	-	-	-	-	-	-	-	-	-	-
Benz[a]anthracene [d]	0.070	0.083	1.6	3.1	-	-	-	6.2	6.2	0.070	0.083	NGR	NGR	-	-

Table A-1. Surface Soil Remediation Guideline Values for Natural Area Land Use - All Exposure Pathway

This table must <u>not</u> be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Tables 1, 3 and 4.
This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Receptor	Overall Guideline		Human		Ecological									Other	
Pathway			Protection of Domestic Use Aquifer		Direct Soil Contact		Nutrient Energy Cycling Check	Livestock Soil and Food Ingestion	Wildlife Soil and Food Ingestion	Protection of Freshwater Aquatic Life		Protection of Wildlife Water		Management Limit	
Soil Type	Fine	Coarse	Fine	Coarse	Fine	Coarse		-	-	Fine	Coarse	Fine	Coarse	Fine	Coarse
Building Type			-	-	-	-	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Benzo[b+j]fluoranthene [d]	6.2	6.2	0.74	1.4	-	-	-	6.2	6.2	NGR	NGR	NGR	NGR	-	-
Benzo[k]fluoranthene [d]	6.2	6.2	0.16	0.31	-	-	-	6.2	6.2	NGR	NGR	NGR	NGR	-	-
Benzo[g,h,i]perylene	-	-	32	63	-	-	-	-	-	NGR	NGR	-	-	-	-
Benzo[a]pyrene [d]	0.6	0.6	1.7	3.4	20	20	-	0.6	0.6	0.70	0.77	NGR	NGR	-	-
Chrysene [d]	6.2	6.2	10	19	-	-	-	6.2	6.2	NGR	NGR	NGR	NGR	-	-
Dibenz[a,h]anthracene [d]	7.4	8.4	1.1	2.1	-	-	-	-	-	7.4	8.4	-	-	-	-
Indeno[1,2,3-c,d]pyrene	-	-	13	24	-	-	-	-	-	NGR	NGR	-	-	-	-
Chlorinated Aliphatics															
Vinyl chloride	0.014	0.02	0.014	0.02	-	-	-	-	-	-	-	-	-	-	-
1,1-Dichloroethene	0.15	0.24	0.15	0.24	-	-	-	-	-	-	-	-	-	-	-
Trichloroethene (Trichloroethylene, TCE)	0.054	0.081	0.054	0.093	3	3	-	-	-	0.72	0.081	-	-	-	-
Tetrachloroethene (Tetrachloroethylene, Perchloroethylene, PCE)	0.69	0.77	0.77	1.4	-	-	-	-	-	0.69	0.77	-	-	-	-
1,2-Dichloroethane	0.025	0.041	0.025	0.041	-	-	-	-	-	0.12	0.12	-	-	-	-
Dichloromethane (Methylene chloride)	0.1	0.095	0.21	0.32	-	-	-	-	-	0.1	0.095	-	-	-	-
Trichloromethane (Chloroform)	0.0029	0.003	0.62	1.0	-	-	-	-	-	0.0029	0.003	-	-	-	-
Tetrachloromethane (Carbon tetrachloride)	0.059	0.062	0.092	0.16	-	-	-	-	-	0.059	0.062	-	-	-	-
Dibromochloromethane	0.91	1.5	0.91	1.5	-	-	-	-	-	-	-	-	-	-	-
Chlorinated Aromatics															
Chlorobenzene [c]	0.61	1.1	0.61	1.1	-	-	-	-	-	BDL	BDL	-	-	-	-
1,2-Dichlorobenzene [c]	0.097	0.18	0.097	0.18	-	-	-	-	-	BDL	BDL	-	-	-	-
1,4-Dichlorobenzene	0.051	0.098	0.051	0.098	-	-	-	-	-	0.32	0.38	-	-	-	-
1,2,3-Trichlorobenzene	0.26	0.31	1.9	3.6	-	-	-	-	-	0.26	0.31	-	-	-	-
1,2,4-Trichlorobenzene	0.78	0.93	2.0	3.9	-	-	-	-	-	0.78	0.93	-	-	-	-

Table A-1. Surface Soil Remediation Guideline Values for Natural Area Land Use - All Exposure Pathway

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This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Receptor	Overall Guideline		Human		Ecological									Other	
Pathway			Protection of Domestic Use Aquifer		Direct Soil Contact		Nutrient Energy Cycling Check	Livestock Soil and Food Ingestion	Wildlife Soil and Food Ingestion	Protection of Freshwater Aquatic Life		Protection of Wildlife Water		Management Limit	
Soil Type	Fine	Coarse	Fine	Coarse	Fine	Coarse		-	-	Fine	Coarse	Fine	Coarse	Fine	Coarse
Building Type			-	-	-	-	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
1,3,5-Trichlorobenzene	1.9	3.6	1.9	3.6	-	-	-	-	-	-	-	-	-	-	-
1,2,3,4-Tetrachlorobenzene	0.042	0.05	3.1	5.9	-	-	-	-	-	0.042	0.05	-	-	-	-
1,2,3,5-Tetrachlorobenzene	0.37	0.70	0.37	0.70	-	-	-	-	-	-	-	-	-	-	-
1,2,4,5-Tetrachlorobenzene	0.19	0.37	0.19	0.37	-	-	-	-	-	-	-	-	-	-	-
Pentachlorobenzene	3.7	4.5	24	47	-	-	-	-	-	3.7	4.5	-	-	-	-
Hexachlorobenzene	3.6	7	3.6	7	-	-	-	-	-	-	-	-	-	-	-
2,4-Dichlorophenol	0.0029	0.0034	0.018	0.034	-	-	-	-	-	0.0029	0.0034	-	-	-	-
2,4,6-Trichlorophenol	0.19	0.37	0.19	0.37	-	-	-	-	-	0.42	0.5	-	-	-	-
2,3,4,6-Tetrachlorophenol	0.039	0.047	0.16	0.31	-	-	-	-	-	0.039	0.047	-	-	-	-
Pentachlorophenol	0.024	0.029	6	12	11	11	-	-	-	0.024	0.029	-	-	-	-
Dioxins & Furans[f,g]	0.00025	0.00025	-	-	-	-	-	0.00025	0.00025	-	-	-	-	-	-
PCBs	1.3	1.3	-	-	33	33	-	1.3	1.3	-	-	-	-	-	-
Pesticides															
Aldicarb[e]	0.041	0.065	0.041	0.065	-	-	-	-	-	BDL	BDL	-	-	-	-
Aldrin	5.9	7.4	5.9	11	-	-	-	-	-	6.1	7.4	-	-	-	-
Atrazine and metabolites	0.0088	0.01	0.10	0.19	-	-	-	-	-	0.0088	0.01	-	-	-	-
Azniphos-methyl	0.41	0.75	0.41	0.75	-	-	-	-	-	-	-	-	-	-	-
Bendiocarb	0.14	0.21	0.14	0.21	-	-	-	-	-	-	-	-	-	-	-
Bromoxynil	0.044	0.052	0.18	0.35	-	-	-	-	-	0.044	0.052	-	-	-	-
Carbaryl[e]	1.9	3.6	1.9	3.6	-	-	-	-	-	BDL	BDL	-	-	-	-
Carbofuran[e]	0.68	1.2	0.68	1.2	-	-	-	-	-	BDL	BDL	-	-	-	-
Chlorothalonil	0.0084	0.01	27	53	-	-	-	-	-	0.0084	0.01	-	-	-	-
Chlorpyrifos[e]	49	95	49	95	-	-	-	-	-	BDL	BDL	-	-	-	-
Cyanazine[e]	0.12	0.21	0.12	0.21	-	-	-	-	-	BDL	BDL	-	-	-	-

Table A-1. Surface Soil Remediation Guideline Values for Natural Area Land Use - All Exposure Pathway

This table must <u>not</u> be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Tables 1, 3 and 4. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Receptor	Overall Guideline		Human		Ecological									Other	
Pathway			Protection of Domestic Use Aquifer		Direct Soil Contact		Nutrient Energy Cycling Check	Livestock Soil and Food Ingestion	Wildlife Soil and Food Ingestion	Protection of Freshwater Aquatic Life		Protection of Wildlife Water		Management Limit	
Soil Type	Fine	Coarse	Fine	Coarse	Fine	Coarse		-	-	Fine	Coarse	Fine	Coarse	Fine	Coarse
Building Type			-	-	-	-	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
2,4-D [c]	0.43	0.67	0.43	0.67	-	-	-	-	-	BDL	BDL	-	-	-	-
DDT	0.015	0.018	5,900	11,000	12	12	547	0.7	0.7	0.015	0.018	-	-	-	-
Diazinon	2.2	4.2	2.2	4.2	-	-	-	-	-	-	-	-	-	-	-
Dicamba [c]	0.5	0.79	0.5	0.79	-	-	-	-	-	BDL	BDL	-	-	-	-
Dichlofop-methyl	2	2.4	12	24	-	-	-	-	-	2	2	-	-	-	-
Dieldrin	0.011	0.014	0.59	1.1	-	-	-	-	-	0.011	0.014	-	-	-	-
Dimethoate	0.0058	0.0055	0.077	0.12	-	-	-	-	-	0.0058	0.0055	-	-	-	-
Dinoseb [c]	2.8	5.5	2.8	5.5	-	-	-	-	-	BDL	BDL	-	-	-	-
Diquat	11	21	11	21	-	-	-	-	-	-	-	-	-	-	-
Diuron	1.9	3.5	1.9	3.5	-	-	-	-	-	-	-	-	-	-	-
Endosulfan	0.0085	0.01	99	190	-	-	-	-	-	0.0085	0.01	-	-	-	-
Endrin	0.0075	0.009	2.4	4.7	-	-	-	-	-	0.0075	0.009	-	-	-	-
Glyphosate	0.054	0.049	0.95	1.4	-	-	-	-	-	0.054	0.049	-	-	-	-
Heptachlor epoxide [c]	0.039	0.076	0.039	0.076	-	-	-	-	-	BDL	BDL	-	-	-	-
Lindane [c]	0.31	0.6	0.31	0.6	-	-	-	-	-	BDL	BDL	-	-	-	-
Linuron	0.051	0.059	0.56	1.1	-	-	-	-	-	0.051	0.059	-	-	-	-
Malathion [c]	0.82	1.3	0.82	1.3	-	-	-	-	-	BDL	BDL	-	-	-	-
MCPA [c]	0.02	0.032	0.02	0.032	-	-	-	-	-	BDL	BDL	-	-	-	-
Methoxychlor	0.046	0.056	5700	11000	-	-	-	-	-	0.046	0.056	-	-	-	-
Metolachlor	0.048	0.055	1.3	2.4	-	-	-	-	-	0.048	0.055	-	-	-	-
Metribuzin	0.024	0.028	7.8	15	-	-	-	-	-	0.024	0.028	-	-	-	-
Paraquat (as dichloride)	1.1	2.2	1.1	2.2	-	-	-	-	-	-	-	-	-	-	-
Parathion [c]	7.2	14	7.2	14	-	-	-	-	-	BDL	BDL	-	-	-	-
Phorate	0.075	0.14	0.075	0.14	-	-	-	-	-	-	-	-	-	-	-

Table A-1. Surface Soil Remediation Guideline Values for Natural Area Land Use - All Exposure Pathway

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This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Receptor	Overall Guideline		Human		Ecological									Other	
Pathway			Protection of Domestic Use Aquifer		Direct Soil Contact		Nutrient Energy Cycling Check	Livestock Soil and Food Ingestion	Wildlife Soil and Food Ingestion	Protection of Freshwater Aquatic Life		Protection of Wildlife Water		Management Limit	
Soil Type	Fine	Coarse	Fine	Coarse	Fine	Coarse		-	-	Fine	Coarse	Fine	Coarse	Fine	Coarse
Building Type			-	-	-	-	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Picloram	0.024	0.022	0.64	0.94	-	-	-	-	-	0.024	0.022	-	-	-	-
Simazine	0.033	0.038	0.14	0.25	-	-	-	-	-	0.033	0.038	-	-	-	-
Tebuthiuron [c]	2.5	3.7	2.5	3.7	-	-	-	-	-	BDL	BDL	-	-	-	-
Terbufos	0.08	0.15	0.08	0.15	-	-	-	-	-	-	-	-	-	-	-
Toxaphene [c]	3.3	6.3	3.3	6.3	-	-	-	-	-	BDL	BDL	-	-	-	-
Triallate	0.0077	0.0092	16	31	-	-	-	-	-	0.0077	0.0092	-	-	-	-
Trifluarin	0.038	0.045	35	67	-	-	-	-	-	0.038	0.045	-	-	-	-
Other Organics															
Aniline [c]	0.36	0.6	0.36	0.6	-	-	-	-	-	BDL	BDL	-	-	-	-
Bis(2-ethyl-hexyl)phthalate	34	41	3,600	7,000	-	-	-	-	-	34	41	-	-	-	-
Dibutyl phthalate	0.54	0.65	70	130	-	-	-	-	-	0.54	0.65	-	-	-	-
Dichlorobenzidine	4.2	8.1	4.2	8.1	-	-	-	-	-	-	-	-	-	-	-
Diisopropanolamine	14	17	130	250	360	360	-	-	-	14	17	-	-	-	-
Ethylene glycol	60	62	60	68	1,100	1,100	1,700	-	-	89	62	-	-	-	-
Hexachlorobutadiene	0.026	0.031	0.5	0.95	-	-	-	-	-	0.026	0.031	-	-	-	-
Methylmethacrylate	1.3	1.8	1.3	1.8	-	-	-	-	-	-	-	-	-	-	-
MTBE	0.044	0.062	0.044	0.062	-	-	-	-	-	7.1	6.1	-	-	-	-
Nonylphenol + ethoxylates	2.7	3.3	-	-	5.7	5.7	-	-	-	2.7	3.3	-	-	-	-
Phenol	0.0028	0.0024	1.6	2.3	20	20	-	-	-	0.0028	0.0024	-	-	-	-
Sulfolane	0.18	0.21	0.18	0.21	210	210	-	-	-	24	18	-	-	-	-

Table A-1. Surface Soil Remediation Guideline Values for Natural Area Land Use - All Exposure Pathway

This table must <u>not</u> be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Tables 1, 3 and 4. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Notes:

a. For more information see Guidelines for the Remediation and Disposal of Sulphur Contaminated Solid Wastes (AEP, 1996)

b. For more information see Soil Quality Guidelines for Barite: Environmental Health and Human Health (AENV, 2004)

c. The Index of Additive Cancer Risk (IACR) is calculated by dividing the soil concentration of each carcinogenic PAH by its Protection of Domestic Use Aquifer guideline value to calculate a hazard index for each PAH and subsequently summing the hazard indexes for the entire PAH mixture, as follows:

Fine Soil:

$$IACR = \frac{[Benz(a)anthracene]}{1.6\ mg \cdot kg^{-1}} + \frac{[Benzo(b+j)fluoranthene]}{0.74\ mg \cdot kg^{-1}} + \frac{[Benzo(k)fluoranthene]}{0.16\ mg \cdot kg^{-1}} + \frac{[Benzo(g,h,i)perylene]}{32\ mg \cdot kg^{-1}} + \frac{[Benzo(a)pyrene]}{1.7\ mg \cdot kg^{-1}} + \frac{[Chrysene]}{10\ mg \cdot kg^{-1}} + \frac{[Dibenz(a,h)anthracene]}{1.1\ mg \cdot kg^{-1}} + \frac{[Indeno(1,2,3-c,d)pyrene]}{13\ mg \cdot kg^{-1}}$$

Coarse Soil:

$$IACR = \frac{[Benz(a)anthracene]}{3.1\ mg \cdot kg^{-1}} + \frac{[Benzo(b+j)fluoranthene]}{1.4\ mg \cdot kg^{-1}} + \frac{[Benzo(k)fluoranthene]}{0.31\ mg \cdot kg^{-1}} + \frac{[Benzo(g,h,i)perylene]}{63\ mg \cdot kg^{-1}} + \frac{[Benzo(a)pyrene]}{3.4\ mg \cdot kg^{-1}} + \frac{[Chrysene]}{19\ mg \cdot kg^{-1}} + \frac{[Dibenz(a,h)anthracene]}{2.1\ mg \cdot kg^{-1}} + \frac{[Indeno(1,2,3-c,d)pyrene]}{24\ mg \cdot kg^{-1}}$$

d. Overall guideline value for ecological receptors only.

e. Guideline for protection of aquatic life is below detection limit, groundwater monitoring is required.

f. Expressed as toxic equivalents (TEQs) based on 2,3,7,8-PCDD (See CCME, 1999 and updates)

g. Guideline values adopted directly from CCME (1999 and updates) without change.

BDL - Below detection limit

NGR - no guideline required, calculated value >1,000,000 mg/kg; or for PAH groundwater protection, calculated value results in groundwater concentration greater than solubility

Table A-2. Surface Soil Remediation Guideline Values for Agricultural Land Use - All Exposure Pathways

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Table 1, 3 and 4.
This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a) .

Receptor	Overall Guideline		Human							Ecological														Other	
Pathway			Direct Soil Contact	Vapour Inhalation				Protection of Domestic Use Aquifer		Direct Soil Contact		Nutrient/ Energy Cycling Check	Livestock Soil and Food Ingestion	Wildlife Soil and Food Ingestion	Protection of Freshwater Aquatic Life		Protection of Livestock Water		Protection of Wildlife Water		Protection of Irrigation Water		Management Limit	
Soil Type	Fine	Coarse	-	Fine	Fine	Coarse	Coarse	Fine	Coarse	Fine	Coarse		-	-	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse
Building Type			-	Basement	Slab	Basement	Slab	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
General and Inorganic Parameters																								
pH (in 0.01M $CaCl_2$)	6-8.5	6-8.5	-	-	-	-	-	-	-	6-8.5	6-8.5	-	-	-	-	-	-	-	-	-	-	-	-	-
Cyanide (free)	0.9	0.9	29	-	-	-	-	-	-	0.9	0.9	-	11	-	-	-	-	-	-	-	-	-	-	-
Fluoride	200	200	-	-	-	-	-	-	-	200	200	-	-	-	-	-	-	-	-	-	-	-	-	-
Sulphur (elemental)[a]	500	500	-	-	-	-	-	-	-	500	500	-	-	-	-	-	-	-	-	-	-	-	-	-
Metals																								
Antimony	20	20	-	-	-	-	-	-	-	20	20	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic (inorganic)	17	17	21	-	-	-	-	-	-	17	17	-	380	-	-	-	-	-	-	-	-	-	-	-
Barium	750	750	-	-	-	-	-	-	-	750	750	-	-	-	-	-	-	-	-	-	-	-	-	-
Barite-barium[b]	3,200	3,200	3,200	-	-	-	-	-	-	180,000	180,000	-	3,300	3,300	-	-	-	-	-	-	-	-	-	-
Beryllium	5	5	-	-	-	-	-	-	-	5	5	-	-	-	-	-	-	-	-	-	-	-	-	-
Boron (hot water soluble)	2	2	-	-	-	-	-	-	-	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	1.4	1.4	1.4	-	-	-	-	-	-	10	10	54	3.8	-	-	-	-	-	-	-	-	-	-	-
Chromium (hexavalent)	0.4	0.4	-	-	-	-	-	-	-	0.4	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-
Chromium (total)	64	64	220	-	-	-	-	-	-	64	64	52	-	-	-	-	-	-	-	-	-	-	-	-
Cobalt	20	20	-	-	-	-	-	-	-	20	20	-	-	-	-	-	-	-	-	-	-	-	-	-
Copper	63	63	1,100	-	-	-	-	-	-	63	63	350	300	-	-	-	-	-	-	-	-	-	-	-
Lead	70	70	140	-	-	-	-	-	-	300	300	723	70	-	-	-	-	-	-	-	-	-	-	-
Mercury (inorganic)	6.6	6.6	6.6	-	-	-	-	-	-	12	12	20	-	-	-	-	-	-	-	-	-	-	-	-
Molybdenum	4	4	-	-	-	-	-	-	-	4	4	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	50	50	-	-	-	-	-	-	-	50	50	146	355	-	-	-	-	-	-	-	-	-	-	-

Table A-2. Surface Soil Remediation Guideline Values for Agricultural Land Use - All Exposure Pathways

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Table 1, 3 and 4.
This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Receptor	Overall Guideline		Human							Ecological													Other	
Pathway			Direct Soil Contact	Vapour Inhalation				Protection of Domestic Use Aquifer		Direct Soil Contact		Nutrient/ Energy Cycling Check	Livestock Soil and Food Ingestion	Wildlife Soil and Food Ingestion	Protection of Freshwater Aquatic Life		Protection of Livestock Water		Protection of Wildlife Water		Protection of Irrigation Water		Management Limit	
Soil Type	Fine	Coarse	-	Fine	Fine	Coarse	Coarse	Fine	Coarse	Fine	Coarse		-	-	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse
Building Type			-	Basement	Slab	Basement	Slab	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Selenium	1	1	80	-	-	-	-	-	-	1	1	-	4.5	-	-	-	-	-	-	-	-	-	-	-
Silver	20	20	-	-	-	-	-	-	-	20	20	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium	1	1	1	-	-	-	-	-	-	1.4	1.4	-	1.0	-	-	-	-	-	-	-	-	-	-	-
Tin	5	5	-	-	-	-	-	-	-	5	5	-	-	-	-	-	-	-	-	-	-	-	-	-
Uranium	23	23	23	-	-	-	-	-	-	33	33	-	500	-	-	-	-	-	-	-	-	-	-	-
Vanadium	130	130	-	-	-	-	-	-	-	130	130	255	-	-	-	-	-	-	-	-	-	-	-	-
Zinc	200	200	-	-	-	-	-	-	-	200	200	200	640	-	-	-	-	-	-	-	-	-	-	-
Hydrocarbons																								
Benzene	0.046	0.073	78	1.7	1.6	0.1	0.073	0.046	0.078	60	31	-	44	18	73	1.6	0.2	0.21	15	0.33	-	-	-	-
Toluene	0.52	0.49	20,000	2,100	1,900	130	95	0.52	0.95	110	75	-	2,500	980	250,000	0.49	26	29	NGR	1,000	-	-	-	-
Ethylbenzene	0.11	0.21	8,500	1,000	930	60	44	0.11	0.21	120	55	-	1,600	640	NGR	540	36	42	NGR	17,000	-	-	-	-
Xylenes	15	12	140,000	280	250	16	12	15	28	65	95	-	6,600	2,600	NGR	250	160	180	NGR	16,000	-	-	-	-
Styrene	0.68	0.8	10,000	250	220	14	10	110	210	-	-	-	-	-	0.68	0.8	-	-	-	-	-	-	-	-
F1	210	24	12,000	710	610	30	24	1,100	2,200	210	210	-	27,000	11,000	30,000	1,300	6,600	7,400	30,000	30,000	-	-	800	700
F2	150	130	6,800	3,600	3,100	160	130	1,500	2,900	150	150	-	25,000	9,800	30,000	520	16,000	19,000	30,000	30,000	-	-	1,000	1,000
F3	1,300	300	15,000	-	-	-	-	-	-	1,300	300	-	30,000	16,000	-	-	-	-	-	-	-	-	3,500	2,500
F4	5,600	2,800	21,000	-	-	-	-	-	-	5,600	2,800	-	21,000	8,400	-	-	-	-	-	-	-	-	10,000	10,000
Acenapthene	0.32	0.38	5,300	120,000	99,000	4,800	3,900	NGR	NGR	-	-	-	21.5	21.5	0.32	0.38	NGR	NGR	NGR	NGR	-	-	-	-
Acenaphthylene	5.0	6.0	-	-	-	-	-	-	-	-	-	-	-	-	5.0	6.0	-	-	-	-	-	-	-	-
Anthracene	0.0046	0.0056	24,000	NGR	NGR	780,000	670,000	NGR	NGR	2.5	2.5	-	61.5	61.5	0.0046	0.0056	NGR	NGR	NGR	NGR	-	-	-	-
Fluoranthene	0.032	0.039	3,500	NGR	NGR	550,000	480,000	NGR	NGR	50	50	-	15.4	15.4	0.032	0.039	NGR	NGR	NGR	NGR	-	-	-	-

Table A-2. Surface Soil Remediation Guideline Values for Agricultural Land Use - All Exposure Pathways

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Table 1, 3 and 4.
This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Receptor	Overall Guideline		Human							Ecological												Other	
Pathway			Direct Soil Contact	Vapour Inhalation				Protection of Domestic Use Aquifer		Direct Soil Contact		Nutrient/ Energy Cycling Check	Livestock Soil and Food Ingestion	Wildlife Soil and Food Ingestion	Protection of Freshwater Aquatic Life		Protection of Livestock Water		Protection of Wildlife Water		Protection of Irrigation Water		Management Limit	
Soil Type	Fine	Coarse	-	Fine	Fine	Coarse	Coarse	Fine	Coarse	Fine	Coarse		-	-	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse
Building Type			-	Basement	Slab	Basement	Slab	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Fluorene	0.29	**0.34**	2,700	270,000	220,000	10,000	8,600	NGR	NGR	-	-	-	15.4	15.4	0.29	0.34	NGR	NGR	NGR	NGR	-	-	-	-
Naphthalene	0.016	**0.018**	1,800	58	51	2.9	2.2	28	53	-	-	-	8.8	8.8	0.016	0.018	NGR	NGR	NGR	NGR	-	-	-	-
Phenanthrene	0.051	**0.061**	-	-	-	-	-	-	-	-	-	-	43	43	0.051	0.061	NGR	NGR	NGR	NGR	-	-	-	-
Pyrene	0.034	**0.040**	2100	NGR	NGR	810,000	730,000	NGR	NGR	-	-	-	7.7	7.7	0.034	0.040	NGR	NGR	NGR	NGR	-	-	-	-
Carcinogenic PAHs (as B(a)P TPE)[c]	IARC<1.0[f]	**IARC<1.0[f]**	5.3[d]	NGR	NGR	NGR	NGR	IARC<1.0[f]	IARC<1.0[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benz[a]anthracene[f]	0.070	**0.083**	-	-	-	-	-	1.6	3.1	-	-	-	6.2	6.2	0.070	0.083	NGR	NGR	NGR	NGR	-	-	-	-
Benzo[b+j]fluoranthene[f]	6.2	**6.2**	-	-	-	-	-	0.74	1.4	-	-	-	6.2	6.2	NGR	NGR	NGR	NGR	NGR	NGR	-	-	-	-
Benzo[k]fluoranthene[f]	6.2	**6.2**	-	-	-	-	-	0.16	0.31	-	-	-	6.2	6.2	NGR	NGR	NGR	NGR	NGR	NGR	-	-	-	-
Benzo[g,h,i]perylene	-	-	-	-	-	-	-	32	63	-	-	-	-	-	NGR	NGR	-	-	-	-	-	-	-	-
Benzo[a]pyrene[f]	0.6	**0.6**	-	-	-	-	-	1.7	3.4	20	20	-	0.6	0.6	0.70	0.77	NGR	NGR	NGR	NGR	-	-	-	-
Chrysene[f]	6.2	**6.2**	-	-	-	-	-	10	19	-	-	-	6.2	6.2	NGR	NGR	NGR	NGR	NGR	NGR	-	-	-	-
Dibenz[a,h]anthracene[f]	7.4	**8.4**	-	-	-	-	-	1.1	2.1	-	-	-	-	-	7.4	8.4	-	-	-	-	-	-	-	-
Indeno[1,2,3-c,d]pyrene	-	-	-	-	-	-	-	13	24	-	-	-	-	-	NGR	NGR	-	-	-	-	-	-	-	-
Chlorinated Aliphatics																								
Vinyl chloride	0.0083	**0.00034**	71	0.099	0.0083	0.00049	0.00034	0.014	0.02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,1-Dichloroethene	0.15	**0.021**	1,900	0.5	0.46	0.03	0.021	0.15	0.24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trichloroethene (Trichloroethylene, TCE)	0.054	**0.012**	35	0.31	0.28	0.017	0.012	0.054	0.093	3	3	-	-	-	0.72	0.081	0.13	0.14	-	-	-	-	-	-
Tetrachloroethene (Tetrachloroethylene, Perchloroethylene, PCE)	0.69	**0.16**	530	4.1	3.7	0.22	0.16	0.77	1.4	-	-	-	-	-	0.69	0.77	-	-	-	-	-	-	-	-
1,2-Dichloroethane	0.0062	**0.0027**	2,800	0.06	0.055	0.0038	0.0027	0.025	0.041	-	-	-	-	-	0.12	0.12	0.0062	0.0062	-	-	-	-	-	-
Dichloromethane	0.052	**0.048**	990	18	16	1.0	0.71	0.21	0.32	-	-	-	-	-	0.1	0.095	0.052	0.048	-	-	-	-	-	-

Table A-2. Surface Soil Remediation Guideline Values for Agricultural Land Use - All Exposure Pathways

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Table 1, 3 and 4.
This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Receptor	Overall Guideline		Human							Ecological												Other	
Pathway			Direct Soil Contact	Vapour Inhalation				Protection of Domestic Use Aquifer		Direct Soil Contact		Nutrient/ Energy Cycling Check	Livestock Soil and Food Ingestion	Wildlife Soil and Food Ingestion	Protection of Freshwater Aquatic Life		Protection of Livestock Water		Protection of Wildlife Water		Protection of Irrigation Water		Management Limit	
Soil Type	Fine	Coarse	-	Fine	Fine	Coarse	Coarse	Fine	Coarse	Fine	Coarse		-	-	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse
Building Type			-	Basement	Slab	Basement	Slab	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
(Methylene chloride)																								
Trichloromethane (Chloroform)	0.0029	**0.001**	220	0.024	0.022	0.002	0.001	0.62	1.0	-	-	-	-	-	0.0029	0.003	0.16	0.17	-	-	-	-	-	-
Tetrachloromethane (Carbon tetrachloride)	0.013	**0.00056**	27	0.014	0.013	0.00077	0.00056	0.092	0.16	-	-	-	-	-	0.059	0.062	0.022	0.023	-	-	-	-	-	-
Dibromochloromethane	0.12	**0.12**	760	11	7.8	0.28	0.27	0.91	1.5	-	-	-	-	-	-	-	0.12	0.12	-	-	-	-	-	-
Chlorinated Aromatics																								
Chlorobenzene [#]	0.39	**0.018**	16,000	0.44	0.39	0.024	0.018	0.61	1.1	-	-	-	-	-	BDL	BDL	-	-	-	-	-	-	-	-
1,2-Dichlorobenzene [#]	0.097	**0.18**	16,000	260	230	14	10	0.097	0.18	-	-	-	-	-	BDL	BDL	-	-	-	-	-	-	-	-
1,4-Dichlorobenzene	0.051	**0.098**	4,200	17	14	0.91	0.67	0.051	0.098	-	-	-	-	-	0.32	0.38	-	-	-	-	-	-	-	-
1,2,3-Trichlorobenzene	0.26	**0.26**	49	8.8	6.8	0.30	0.26	1.9	3.6	-	-	-	-	-	0.26	0.31	-	-	-	-	-	-	-	-
1,2,4-Trichlorobenzene	0.78	**0.23**	38	7.6	6	0.26	0.23	2.0	3.9	-	-	-	-	-	0.78	0.93	-	-	-	-	-	-	-	-
1,3,5-Trichlorobenzene	1.9	**0.13**	46	4.1	3.2	0.14	0.13	1.9	3.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,2,3,4-Tetrachlorobenzene	0.042	**0.05**	75	27	20	0.88	0.84	3.1	5.9	-	-	-	-	-	0.042	0.05	-	-	-	-	-	-	-	-
1,2,3,5-Tetrachlorobenzene	0.37	**0.1**	8.8	3.3	2.5	0.1	0.1	0.37	0.70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,2,4,5-Tetrachlorobenzene	0.19	**0.052**	4.6	1.7	1.3	0.054	0.052	0.19	0.37	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pentachlorobenzene	3.7	**4.5**	22	160	140	7.9	6.1	24	47	-	-	-	-	-	3.7	4.5	-	-	-	-	-	-	-	-
Hexachlorobenzene	0.8	**0.5**	18	13	12	0.64	0.5	3.6	7	-	-	-	-	-	-	-	0.8	0.97	-	-	-	-	-	-
2,4-Dichlorophenol	0.0029	**0.0034**	2,200	170,000	140,000	6,300	5,400	0.018	0.034	-	-	-	-	-	0.0029	0.0034	-	-	-	-	-	-	-	-
2,4,6-Trichlorophenol	0.19	**0.37**	260	11,000	8,200	360	320	0.19	0.37	-	-	-	-	-	0.42	0.5	-	-	-	-	-	-	-	-
2,3,4,6-Tetrachlorophenol	0.039	**0.047**	220	15,000	11,000	480	460	0.16	0.31	-	-	-	-	-	0.039	0.047	-	-	-	-	-	-	-	-
Pentachlorophenol	0.024	**0.029**	230	NGR	NGR	110,000	83,000	6	12	11	11	-	-	-	0.024	0.029	-	-	-	-	-	-	-	-

Table A-2. Surface Soil Remediation Guideline Values for Agricultural Land Use - All Exposure Pathways

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Table 1, 3 and 4.
This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a) .

Receptor	Overall Guideline		Human							Ecological													Other	
Pathway			Direct Soil Contact	Vapour Inhalation				Protection of Domestic Use Aquifer		Direct Soil Contact		Nutrient/ Energy Cycling Check	Livestock Soil and Food Ingestion	Wildlife Soil and Food Ingestion	Protection of Freshwater Aquatic Life		Protection of Livestock Water		Protection of Wildlife Water		Protection of Irrigation Water		Management Limit	
Soil Type	Fine	Coarse	-	Fine	Fine	Coarse	Coarse	Fine	Coarse	Fine	Coarse		-	-	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse
Building Type			-	Basement	Slab	Basement	Slab	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Dioxins & Furans [b,i]	0.000004	**0.000004**	0.000004	-	-	-	-	-	-	-	-	-	0.00025	0.00025	-	-	-	-	-	-	-	-	-	-
PCBs	1.3	**1.3**	22	-	-	-	-	-	-	33	33	-	1.3	1.3	-	-	-	-	-	-	-	-	-	-
Pesticides																								
Aldicarb [g]	0.012	**0.012**	22	-	-	-	-	0.041	0.065	-	-	-	-	-	BDL	BDL	0.012	0.012	-	-	0.06	0.059	-	-
Aldrin	3.4	**3.4**	3.4	-	-	-	-	5.9	11	-	-	-	-	-	6.1	7.4	-	-	-	-	-	-	-	-
Atrazine and metabolites	0.0088	**0.01**	11	-	-	-	-	0.10	0.19	-	-	-	-	-	0.0088	0.01	0.025	0.028	-	-	0.049	0.057	-	-
Azniphos-methyl	0.41	**0.75**	55	-	-	-	-	0.41	0.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bendiocarb	0.14	**0.21**	89	-	-	-	-	0.14	0.21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bromoxynil [g]	0.044	**0.[illegible]2**	11	-	-	-	-	0.18	0.35	-	-	-	-	-	0.044	0.052	0.097	0.11	-	-	BDL	BDL	-	-
Carbaryl [g]	1.9	**3.6**	220	-	-	-	-	1.9	3.6	-	-	-	-	-	BDL	BDL	5.7	6.5	-	-	-	-	-	-
Carbofuran [g]	0.082	**0.089**	220	-	-	-	-	0.68	1.2	-	-	-	-	-	BDL	BDL	0.082	0.089	-	-	-	-	-	-
Chlorothalonil	0.0084	**0.01**	330	-	-	-	-	27	53	-	-	-	-	-	0.0084	0.01	7.9	9.5	-	-	0.27	0.32	-	-
Chlorpyrifos [g]	3.2	**3.8**	220	-	-	-	-	49	95	-	-	-	-	-	BDL	BDL	3.2	3.8	-	-	-	-	-	-
Cyanazine [g]	0.029	**0.032**	29	-	-	-	-	0.12	0.21	-	-	-	-	-	BDL	BDL	0.029	0.032	-	-	BDL	BDL	-	-
2,4-D [g]	0.1	**0.1**	220	-	-	-	-	0.43	0.67	-	-	-	-	-	BDL	BDL	0.1	0.1	-	-	-	-	-	-
DDT	0.015	**0.018**	220	-	-	-	-	5,900	11,000	12	12	547	0.7	0.7	0.015	0.018	1500	1800	-	-	-	-	-	-
Diazinon	2.2	**4.2**	44	-	-	-	-	2.2	4.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dicamba [g]	0.12	**0.12**	280	-	-	-	-	0.5	0.79	-	-	-	-	-	BDL	BDL	0.12	0.12	-	-	BDL	BDL	-	-
Dichlofop-methyl	0.059	**0.071**	22	-	-	-	-	12	24	-	-	-	-	-	2	2.4	3	3.6	-	-	0.059	0.071	-	-
Dieldrin	0.011	**0.014**	3.4	-	-	-	-	0.59	1.1	-	-	-	-	-	0.011	0.014	-	-	-	-	-	-	-	-
Dimethoate	0.0028	**0.0027**	44	-	-	-	-	0.077	0.12	-	-	-	-	-	0.0058	0.0055	0.0028	0.0027	-	-	-	-	-	-

Table A-2. Surface Soil Remediation Guideline Values for Agricultural Land Use - All Exposure Pathways

This table must <u>not</u> be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Table 1, 3 and 4.
This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Receptor	Overall Guideline		Human							Ecological												Other	
Pathway			Direct Soil Contact	Vapour Inhalation				Protection of Domestic Use Aquifer		Direct Soil Contact		Nutrient/ Energy Cycling Check	Livestock Soil and Food Ingestion	Wildlife Soil and Food Ingestion	Protection of Freshwater Aquatic Life		Protection of Livestock Water		Protection of Wildlife Water		Protection of Irrigation Water		Management Limit	
Soil Type	Fine	Coarse	-	Fine	Fine	Coarse	Coarse	Fine	Coarse	Fine	Coarse		-	-	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse
Building Type			-	Basement	Slab	Basement	Slab	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Dinoseb [6]	1.1	1.3	22	-	-	-	-	2.8	5.5	-	-	-	-	-	BDL	BDL	10	12	-	-	1.1	1.3	-	-
Diquat	11	21	180	-	-	-	-	11	21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diuron	1.9	3.5	350	-	-	-	-	1.9	3.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Endosulfan	0.0085	0.01	210	-	-	-	-	99	190	-	-	-	-	-	0.0085	0.01	-	-	-	-	-	-	-	-
Endrin	0.0075	0.009	10	-	-	-	-	2.4	4.7	-	-	-	-	-	0.0075	0.009	-	-	-	-	-	-	-	-
Glyphosate	0.054	0.049	670	-	-	-	-	0.95	1.4	-	-	-	-	-	0.054	0.049	0.23	0.21	-	-	-	-	-	-
Heptachlor epoxide [5]	0.039	0.010	0.46	0.31	0.21	0.010	0.012	0.039	0.076	-	-	-	-	-	BDL	BDL	-	-	-	-	-	-	-	-
Lindane [5]	0.11	0.13	6.7	-	-	-	-	0.31	0.6	-	-	-	-	-	BDL	BDL	0.11	0.13	-	-	-	-	-	-
Linuron [6]	0.051	0.059	44	-	-	-	-	0.56	1.1	-	-	-	-	-	0.051	0.059	-	-	-	-	BDL	BDL	-	-
Malathion [5]	0.82	1.3	440	-	-	-	-	0.82	1.3	-	-	-	-	-	BDL	BDL	-	-	-	-	-	-	-	-
MCPA [6]	0.02	0.025	11	-	-	-	-	0.02	0.032	-	-	-	-	-	BDL	BDL	0.026	0.025	-	-	BDL	BDL	-	-
Methoxychlor	0.046	0.056	3500	-	-	-	-	0.046	0.056	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Metolachlor	0.048	0.055	110	-	-	-	-	1.3	2.4	-	-	-	-	-	0.048	0.055	0.3	0.35	-	-	0.17	0.2	-	-
Metribuzin	0.012	0.014	180	-	-	-	-	7.8	15	-	-	-	-	-	0.024	0.028	1.9	2.2	-	-	0.012	0.014	-	-
Paraquat (as dichloride)	1.1	2.2	22	-	-	-	-	1.1	2.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Parathion [6]	7.2	14	110	-	-	-	-	7.2	14	-	-	-	-	-	BDL	BDL	-	-	-	-	-	-	-	-
Phorate	0.075	0.14	4.4	-	-	-	-	0.075	0.14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Picloram	0.024	0.022	440	-	-	-	-	0.64	0.94	-	-	-	-	-	0.024	0.022	0.15	0.14	-	-	-	-	-	-
Simazine [6]	0.033	0.038	29	-	-	-	-	0.14	0.25	-	-	-	-	-	0.033	0.038	0.033	0.038	-	-	BDL	BDL	-	-
Tebuthiuron [5]	0.12	0.11	1600	-	-	-	-	2.5	3.7	-	-	-	-	-	BDL	BDL	0.12	0.11	-	-	BDL	BDL	-	-
Terbufos	0.08	0.15	1.1	-	-	-	-	0.08	0.15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table A-2. Surface Soil Remediation Guideline Values for Agricultural Land Use - All Exposure Pathways

This table must <u>not</u> be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Table 1, 3 and 4.
This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Receptor	Overall Guideline		Human							Ecological													Other	
Pathway			Direct Soil Contact	Vapour Inhalation				Protection of Domestic Use Aquifer		Direct Soil Contact		Nutrient/ Energy Cycling Check	Livestock Soil and Food Ingestion	Wildlife Soil and Food Ingestion	Protection of Freshwater Aquatic Life		Protection of Livestock Water		Protection of Wildlife Water		Protection of Irrigation Water		Management Limit	
Soil Type	Fine	Coarse	-	Fine	Fine	Coarse	Coarse	Fine	Coarse	Fine	Coarse		-	-	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse
Building Type			-	Basement	Slab	Basement	Slab	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Toxaphene [5]	3.3	4.8	4.8	4,600	3,100	150	170	3.3	6.3	-	-	-	-	-	BDL	BDL	-	-	-	-	-	-	-	-
Triallate	0.0077	0.0092	290	-	-	-	-	16	31	-	-	-	-	-	0.0077	0.0092	7.4	8.8	-	-	-	-	-	-
Trifluarin	0.038	0.045	110	-	-	-	-	35	67	-	-	-	-	-	0.038	0.045	8.4	10	-	-	-	-	-	-
Other Organics																								
Aniline [5]	0.36	0.6	160	720	640	34	26	0.36	0.6	-	-	-	-	-	BDL	BDL	-	-	-	-	-	-	-	-
Bis(2-ethyl-hexyl)phthalate	34	41	1,000	NGR	NGR	NGR	NGR	3,600	7,000	-	-	-	-	-	34	41	-	-	-	-	-	-	-	-
Dibutyl phthalate	0.54	0.65	1,300	22,0000	18,0000	9,200	7,400	70	130	-	-	-	-	-	0.54	0.65	-	-	-	-	-	-	-	-
Dichlorobenzidine	4.2	8.1	130	NGR	NGR	NGR	NGR	4.2	8.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diisopropanolamine	14	17	22,000	-	-	-	-	130	250	360	360	-	-	-	14	17	-	-	-	-	16	18	-	-
Ethylene glycol	60	62	73,000	NGR	NGR	120,000	86,000	60	68	1,100	1,100	1,700	-	-	89	62	-	-	-	-	-	-	-	-
Hexachlorobutadiene	0.026	0.0067	210	0.18	0.16	0.0087	0.0067	0.5	0.95	-	-	-	-	-	0.026	0.031	-	-	-	-	-	-	-	-
Methylmethacrylate	1.3	0.10	1,100	3.4	3.0	0.14	0.10	1.3	1.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MTBE	0.044	0.046	380	1.2	1.1	0.065	0.046	0.044	0.062	-	-	-	-	-	7.1	6.1	-	-	-	-	-	-	-	-
Nonylphenol + ethoxylates	2.7	3.3	-	-	-	-	-	-	-	5.7	5.7	-	-	-	2.7	3.3	-	-	-	-	-	-	-	-
Phenol	0.0014	0.0012	2,000	14,000	13,000	660	480	1.6	2.3	20	20	-	-	-	0.0028	0.0024	0.0014	0.0012	-	-	-	-	-	-
Sulfolane	0.18	0.18	350	-	-	-	-	0.18	0.21	210	210	-	-	-	24	18	-	-	-	-	0.24	0.18	-	-

Table A-2. Surface Soil Remediation Guideline Values for Agricultural Land Use - All Exposure Pathways

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Table 1, 3 and 4.
This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a) .

Notes:

a. For more information see Guidelines for the Remediation and Disposal of Sulphur Contaminated Solid Wastes (AEP, 1996)

b. For more information see Soil Quality Guidelines for Barite: Environmental Health and Human Health (AENV, 2004)

c. Human health direct soil contact guidelines for carcinogenic PAHs are based on B[a]P Total Potency Equivalents (TPE). TPEs are calculated by multiplying the soil concentration of individual carcinogenic PAHs by a standardized Benzo[a]pyrene Potency Equivalence Factor (PEF) to produce a Benzo[a]pyrene relative potency concentration, and by subsequently summing the relative potency concentrations for the entire PAH mixture. B[a]P PEFs are order of magnitude estimates of carcinogenic potential and are based on the World Health Organization (WHO/IPCS, 1998) scheme, as follows:

Carcinogenic PAH Compound	PEF
Benz[a]anthracene	0.1
Benzo(b+j)fluoranthene	0.1
Benzo[k]fluoranthene	0.1
Benzo[ghi]perylene	0.01
Benzo[a]pyrene	1
Chrysene	0.01
Dibenz[a,h]anthracene	1
Indeno[1,2,3-c,d]pyrene	0.1

d. The B[a]P Total Potency Equivalents (TPEs) calculated for specific soil samples using Potency Equivalency Factors (PEFs) should be multiplied by an Uncertainty Factor of 3 when evaluating PAH mixtures associated with creosote or coal tar-type environmental releases, prior to evaluating against the human health direct contact soil remediation guideline.

e. The Index of Additive Cancer Risk (IACR) is calculated by dividing the soil concentration of each carcinogenic PAH by its Protection of Domestic Use Aquifer guideline value to calculate a hazard index for each PAH and subsequently summing the hazard indexes for the entire PAH mixture, as follows:

Fine Soil:

$$IACR = \frac{[Benz(a)anthracene]}{1.6\ mg \cdot kg^{-1}} + \frac{[Benzo(b+j)fluoranthene]}{0.74\ mg \cdot kg^{-1}} + \frac{[Benzo(k)fluoranthene]}{0.16\ mg \cdot kg^{-1}} + \frac{[Benzo(g,h,i)perylene]}{32\ mg \cdot kg^{-1}} + \frac{[Benzo(a)pyrene]}{1.7\ mg \cdot kg^{-1}} + \frac{[Chrysene]}{10\ mg \cdot kg^{-1}} + \frac{[Dibenz(a,h)anthracene]}{1.1\ mg \cdot kg^{-1}} + \frac{[Indeno(1,2,3-c,d)pyrene]}{13\ mg \cdot kg^{-1}}$$

Coarse Soil:

$$IACR = \frac{[Benz(a)anthracene]}{3.1\ mg \cdot kg^{-1}} + \frac{[Benzo(b+j)fluoranthene]}{1.4\ mg \cdot kg^{-1}} + \frac{[Benzo(k)fluoranthene]}{0.31\ mg \cdot kg^{-1}} + \frac{[Benzo(g,h,i)perylene]}{63\ mg \cdot kg^{-1}} + \frac{[Benzo(a)pyrene]}{3.4\ mg \cdot kg^{-1}} + \frac{[Chrysene]}{19\ mg \cdot kg^{-1}} + \frac{[Dibenz(a,h)anthracene]}{2.1\ mg \cdot kg^{-1}} + \frac{[Indeno(1,2,3-c,d)pyrene]}{24\ mg \cdot kg^{-1}}$$

f. Overall guideline value for ecological receptors only.

g. Guideline for protection of aquatic life or irrigation water is below detection limit, groundwater monitoring is required.

h. Expressed as toxic equivalents (TEQs) based on 2,3,7,8-PCDD (See CCME, 1999 and updates)

i. Guideline values adopted directly from CCME (1999 and updates) without change.

BDL - Below detection limit

NGR - no guideline required, calculated value >1,000,000 mg/kg; or for PAH groundwater protection, calculated value results in groundwater concentration greater than solubility.

Table A-3. Surface Soil Remediation Guideline Values for Residential/Parkland Land Use - All Exposure Pathways

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Tables 1, 3 and 4. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Receptor	Overall Guideline		Human							Ecological					Other	
Pathway			Direct Soil Contact	Vapour Inhalation				Protection of Domestic Use Aquifer		Direct Soil Contact		Nutrient/ Energy Cycling Check	Protection of Freshwater Aquatic Life		Management Limit	
Soil Type	Fine	Coarse	-	Fine	Fine	Coarse	Coarse	Fine	Coarse	Fine	Coarse		Fine	Coarse	Fine	Coarse
Building Type			-	Basement	Slab	Basement	Slab	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
General and Inorganic Parameters																
pH (in 0.01M $CaCl_2$)	6-8.5	6-8.5	-	-	-	-	-	-	-	6-8.5	6-8.5	-	-	-	-	-
Cyanide (free)	0.9	0.9	29	-	-	-	-	-	-	0.9	0.9	-	-	-	-	-
Fluoride	200	200	-	-	-	-	-	-	-	200	200	-	-	-	-	-
Sulphur (elemental)[a]	500	500	-	-	-	-	-	-	-	500	500	-	-	-	-	-
Metals																
Antimony	20	20	-	-	-	-	-	-	-	20	20	-	-	-	-	-
Arsenic (inorganic)	17	17	21	-	-	-	-	-	-	17	17	-	-	-	-	-
Barium	500	500	-	-	-	-	-	-	-	500	500	-	-	-	-	-
Barite-barium[b]	3,200	3,200	3,200	-	-	-	-	-	-	180,000	180,000	-	-	-	-	-
Beryllium	5	5	-	-	-	-	-	-	-	5	5	-	-	-	-	-
Boron (hot water soluble)	2	2	-	-	-	-	-	-	-	2	2	-	-	-	-	-
Cadmium	10	10	14	-	-	-	-	-	-	10	10	54	-	-	-	-
Chromium (hexavalent)	0.4	0.4	-	-	-	-	-	-	-	0.4	0.4	-	-	-	-	-
Chromium (total)	64	64	220	-	-	-	-	-	-	64	64	52	-	-	-	-
Cobalt	20	20	-	-	-	-	-	-	-	20	20	-	-	-	-	-
Copper	63	63	1,100	-	-	-	-	-	-	63	63	350	-	-	-	-
Lead	140	140	140	-	-	-	-	-	-	300	300	723	-	-	-	-

Table A-3. Surface Soil Remediation Guideline Values for Residential/Parkland Land Use - All Exposure Pathways

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Tables 1, 3 and 4.
This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a) .

Receptor	Overall Guideline		Human							Ecological					Other	
Pathway			Direct Soil Contact	Vapour Inhalation				Protection of Domestic Use Aquifer		Direct Soil Contact		Nutrient/ Energy Cycling Check	Protection of Freshwater Aquatic Life		Management Limit	
Soil Type	Fine	Coarse	-	Fine	Fine	Coarse	Coarse	Fine	Coarse	Fine	Coarse		Fine	Coarse	Fine	Coarse
Building Type			-	Basement	Slab	Basement	Slab	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Mercury (inorganic)	6.6	6.6	6.6	-	-	-	-	-	-	12	12	20	-	-	-	-
Molybdenum	4	4	-	-	-	-	-	-	-	4	4	-	-	-	-	-
Nickel	50	50	-	-	-	-	-	-	-	50	50	146	-	-	-	-
Selenium	1	1	80	-	-	-	-	-	-	1	1	-	-	-	-	-
Silver	20	20	-	-	-	-	-	-	-	20	20	-	-	-	-	-
Thallium	1	1	1	-	-	-	-	-	-	1.4	1.4	-	-	-	-	-
Tin	5	5	-	-	-	-	-	-	-	5	5	-	-	-	-	-
Uranium	23	23	23	-	-	-	-	-	-	500	500	-	-	-	-	-
Vanadium	130	130	-	-	-	-	-	-	-	130	130	255	-	-	-	-
Zinc	200	200	-	-	-	-	-	-	-	200	200	200	-	-	-	-
Hydrocarbons																
Benzene	0.046	0.073	78	1.7	1.6	0.1	0.073	0.046	0.078	60	31	-	73	1.6	-	-
Toluene	0.52	0.49	20,000	2,100	1,900	130	95	0.52	0.95	110	75	-	250,000	0.49	-	-
Ethylbenzene	0.11	0.21	8,500	1,000	930	60	44	0.11	0.21	120	55	-	NGR	540	-	-
Xylenes	15	12	140,000	280	250	16	12	15	28	65	95	-	NGR	250	-	-
Styrene	0.68	0.8	10,000	250	220	14	10	110	210	-	-	-	0.68	0.8	-	-
F1	210	24	12,000	710	610	30	24	1,100	2,200	210	210	-	30,000	1,300	800	700
F2	150	130	6,800	3,600	3,100	160	130	1,500	2,900	150	150	-	30,000	520	1,000	1,000

Table A-3. Surface Soil Remediation Guideline Values for Residential/Parkland Land Use - All Exposure Pathways

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Tables 1, 3 and 4.
This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Receptor	Overall Guideline		Human							Ecological					Other	
Pathway			Direct Soil Contact	Vapour Inhalation				Protection of Domestic Use Aquifer		Direct Soil Contact		Nutrient/ Energy Cycling Check	Protection of Freshwater Aquatic Life		Management Limit	
Soil Type	Fine	Coarse	-	Fine	Fine	Coarse	Coarse	Fine	Coarse	Fine	Coarse		Fine	Coarse	Fine	Coarse
Building Type			-	Basement	Slab	Basement	Slab	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
F3	1,300	300	15,000	-	-	-	-	-	-	1,300	300	-	-	-	3,500	2,500
F4	5,600	2,800	21,000	-	-	-	-	-	-	5,600	2,800	-	-	-	10,000	10,000
Acenapthene	0.32	0.38	5,300	120,000	99,000	4,800	3,900	NGR	NGR	-	-	-	0.32	0.38	-	-
Acenaphthylene	5.0	6.0	-	-	-	-	-	-	-	-	-	-	5.0	6.0	-	-
Anthracene	0.0046	0.0056	24,000	NGR	NGR	780,000	670,000	NGR	NGR	2.5	2.5	-	0.0046	0.0056	-	-
Fluoranthene	0.032	0.039	3,500	NGR	NGR	550,000	480,000	NGR	NGR	50	50	-	0.032	0.039	-	-
Fluorene	0.29	0.34	2,700	270,000	220,000	10,000	8,600	NGR	NGR	-	-	-	0.29	0.34	-	-
Naphthalene	0.016	0.018	1800	58	51	2.9	2.2	28	53	-	-	-	0.016	0.018	-	-
Phenanthrene	0.051	0.061	-	-	-	-	-	-	-	-	-	-	0.051	0.061	-	-
Pyrene	0.034	0.040	2,100	NGR	NGR	810,000	730,000	NGR	NGR	-	-	-	0.034	0.040	-	-
Carcinogenic PAHs (as B(a)P TPE)[c]	IARC<1.0 [e]	IARC<1.0 [e]	5.3 [d]	NGR	NGR	NGR	NGR	IARC<1.0 [e]	IARC<1.0 [e]	-	-	-	-	-	-	-
Benz[a]anthracene [f]	0.070	0.083	-	-	-	-	-	1.6	3.1	-	-	-	0.070	0.083	-	-
Benzo[b+j]fluoranthene	-	-	-	-	-	-	-	0.74	1.4	-	-	-	NGR	NGR	-	-
Benzo[k]fluoranthene	-	-	-	-	-	-	-	0.16	0.31	-	-	-	NGR	NGR	-	-
Benzo[g,h,i]perylene	-	-	-	-	-	-	-	32	63	-	-	-	NGR	NGR	-	-
Benzo[a]pyrene [f]	0.7	0.77	-	-	-	-	-	1.7	3.4	20	20	-	0.70	0.77	-	-
Chrysene	-	-	-	-	-	-	-	10	19	-	-	-	NGR	NGR	-	-
Dibenz[a,h]anthracene [f]	7.4	8.4	-	-	-	-	-	1.1	2.1	-	-	-	7.4	8.4	-	-

Table A-3. Surface Soil Remediation Guideline Values for Residential/Parkland Land Use - All Exposure Pathways

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Tables 1, 3 and 4.
This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Receptor	Overall Guideline		Human							Ecological					Other	
Pathway			Direct Soil Contact	Vapour Inhalation				Protection of Domestic Use Aquifer		Direct Soil Contact		Nutrient/ Energy Cycling Check	Protection of Freshwater Aquatic Life		Management Limit	
Soil Type	Fine	Coarse	-	Fine	Fine	Coarse	Coarse	Fine	Coarse	Fine	Coarse		Fine	Coarse	Fine	Coarse
Building Type			-	Basement	Slab	Basement	Slab	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Indeno[1,2,3-c,d]pyrene	-	-	-	-	-	-	-	13	24	-	-	-	NGR	NGR	-	-
Chlorinated Aliphatics																
Vinyl chloride	0.0083	**0.00034**	71	0.009	0.0083	0.00049	0.00034	0.014	0.02	-	-	-	-	-	-	-
1,1-Dichloroethene	0.15	**0.021**	1,900	0.5	0.46	0.03	0.021	0.15	0.24	-	-	-	-	-	-	-
Trichloroethene (Trichloroethylene, TCE)	0.054	**0.012**	35	0.31	0.28	0.017	0.012	0.054	0.093	3	3	-	0.72	0.081	-	-
Tetrachloroethene (Tetrachloroethylene, Perchloroethylene, PCE)	0.69	**0.16**	530	4.1	3.7	0.22	0.16	0.77	1.4	-	-	-	0.69	0.77	-	-
1,2-Dichloroethane	0.025	**0.0027**	2,800	0.06	0.055	0.0038	0.0027	0.025	0.041	-	-	-	0.12	0.12	-	-
Dichloromethane (Methylene chloride)	0.1	**0.095**	990	18	16	1.0	0.71	0.21	0.32	-	-	-	0.1	0.095	-	-
Trichloromethane (Chloroform)	0.0029	**0.001**	220	0.024	0.022	0.002	0.001	0.62	1.0	-	-	-	0.0029	0.003	-	-
Tetrachloromethane (Carbon tetrachloride)	0.013	**0.00056**	27	0.014	0.013	0.00077	0.00056	0.092	0.16	-	-	-	0.059	0.062	-	-
Dibromochloromethane	0.91	**0.27**	760	11	7.8	0.28	0.27	0.91	1.5	-	-	-	-	-	-	-
Chlorinated Aromatics																
Chlorobenzene [g]	0.39	**0.018**	16,000	0.44	0.39	0.024	0.018	0.61	1.1	-	-	-	BDL	BDL	-	-
1,2-Dichlorobenzene [g]	0.097	**0.18**	16,000	260	230	14	10	0.097	0.18	-	-	-	BDL	BDL	-	-
1,4-Dichlorobenzene	0.051	**0.098**	4,200	17	14	0.91	0.67	0.051	0.098	-	-	-	0.32	0.38	-	-
1,2,3-Trichlorobenzene	0.26	**0.26**	49	8.8	6.8	0.30	0.26	1.9	3.6	-	-	-	0.26	0.31	-	-

Table A-3. Surface Soil Remediation Guideline Values for Residential/Parkland Land Use - All Exposure Pathways

This table must <u>not</u> be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Tables 1, 3 and 4. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Receptor	Overall Guideline		Human							Ecological					Other	
Pathway			Direct Soil Contact	Vapour Inhalation				Protection of Domestic Use Aquifer		Direct Soil Contact		Nutrient/ Energy Cycling Check	Protection of Freshwater Aquatic Life		Management Limit	
Soil Type	Fine	Coarse	-	Fine	Fine	Coarse	Coarse	Fine	Coarse	Fine	Coarse		Fine	Coarse	Fine	Coarse
Building Type			-	Basement	Slab	Basement	Slab	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
1,2,4-Trichlorobenzene	0.78	**0.23**	38	7.6	6	0.26	0.23	2.0	3.9	-	-	-	0.78	0.93	-	-
1,3,5-Trichlorobenzene	1.9	**0.13**	46	4.1	3.2	0.14	0.13	1.9	3.6	-	-	-	-	-	-	-
1,2,3,4-Tetrachlorobenzene	0.042	**0.05**	75	27	20	0.88	0.84	3.1	5.9	-	-	-	0.042	0.05	-	-
1,2,3,5-Tetrachlorobenzene	0.37	**0.10**	8.8	3.3	2.5	0.10	0.10	0.37	0.70	-	-	-	-	-	-	-
1,2,4,5-Tetrachlorobenzene	0.19	**0.052**	4.6	1.7	1.3	0.054	0.052	0.19	0.37	-	-	-	-	-	-	-
Pentachlorobenzene	3.7	**4.5**	22	160	140	7.9	6.1	24	47	-	-	-	3.7	4.5	-	-
Hexachlorobenzene	3.6	**0.5**	18	13	12	0.64	0.50	3.6	7	-	-	-	-	-	-	-
2,4-Dichlorophenol	0.0029	**0.0034**	2,200	170,000	140,000	6,300	5,400	0.018	0.034	-	-	-	0.0029	0.0034	-	-
2,4,6-Trichlorophenol	0.19	**0.37**	260	11,000	8,200	360	320	0.19	0.37	-	-	-	0.42	0.5	-	-
2,3,4,6-Tetrachlorophenol	0.039	**0.047**	220	15,000	11,000	480	460	0.16	0.31	-	-	-	0.039	0.047	-	-
Pentachlorophenol	0.024	**0.029**	230	NGR	NGR	110,000	83,000	6	12	11	11	-	0.024	0.029	-	-
Dioxins & Furans [b,i]	0.000004	**0.000004**	0.000004	-	-	-	-	-	-	-	-	-	-	-	-	-
PCBs	22	**22**	22	-	-	-	-	-	-	33	33	-	-	-	-	-
Pesticides																
Aldicarb [g]	0.041	**0.065**	22	-	-	-	-	0.041	0.065	-	-	-	BDL	BDL	-	-
Aldrin	3.4	**3.4**	3.4	-	-	-	-	5.9	11	-	-	-	6.1	7.4	-	-
Atrazine and metabolites	0.0088	**0.01**	11	-	-	-	-	0.10	0.19	-	-	-	0.0088	0.01	-	-
Azniphos-methyl	0.41	**0.75**	55	-	-	-	-	0.41	0.75	-	-	-	-	-	-	-

Table A-3. Surface Soil Remediation Guideline Values for Residential/Parkland Land Use - All Exposure Pathways

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Tables 1, 3 and 4.
This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a) .

Receptor	Overall Guideline		Human							Ecological					Other	
Pathway			Direct Soil Contact	Vapour Inhalation				Protection of Domestic Use Aquifer		Direct Soil Contact		Nutrient/ Energy Cycling Check	Protection of Freshwater Aquatic Life		Management Limit	
Soil Type	Fine	Coarse	-	Fine	Fine	Coarse	Coarse	Fine	Coarse	Fine	Coarse		Fine	Coarse	Fine	Coarse
Building Type			-	Basement	Slab	Basement	Slab	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Bendiocarb	0.14	0.21	89	-	-	-	-	0.14	0.21	-	-	-	-	-	-	-
Bromoxynil	0.044	0.052	11	-	-	-	-	0.18	0.35	-	-	-	0.044	0.052	-	-
Carbaryl [g]	1.9	3.6	220	-	-	-	-	1.9	3.6	-	-	-	BDL	BDL	-	-
Carbofuran [g]	0.68	1.2	220	-	-	-	-	0.68	1.2	-	-	-	BDL	BDL	-	-
Chlorothalonil	0.0084	0.01	330	-	-	-	-	27	53	-	-	-	0.0084	0.01	-	-
Chlorpyrifos [g]	49	95	220	-	-	-	-	49	95	-	-	-	BDL	BDL	-	-
Cyanazine [g]	0.12	0.21	29	-	-	-	-	0.12	0.21	-	-	-	BDL	BDL	-	-
2,4-D [g]	0.43	0.67	220	-	-	-	-	0.43	0.67	-	-	-	BDL	BDL	-	-
DDT	0.015	0.018	220	-	-	-	-	5,900	11,000	12	12	547	0.015	0.018	-	-
Diazinon	2.2	4.2	44	-	-	-	-	2.2	4.2	-	-	-	-	-	-	-
Dicamba [g]	0.5	0.79	280	-	-	-	-	0.5	0.79	-	-	-	BDL	BDL	-	-
Dichlofop-methyl	2	2.4	22	-	-	-	-	12	24	-	-	-	2	2.4	-	-
Dieldrin	0.011	0.014	3.4	-	-	-	-	0.59	1.1	-	-	-	0.011	0.014	-	-
Dimethoate	0.0058	0.0055	44	-	-	-	-	0.077	0.12	-	-	-	0.0058	0.0055	-	-
Dinoseb [g]	2.8	5.5	22	-	-	-	-	2.8	5.5	-	-	-	BDL	BDL	-	-
Diquat	11	21	180	-	-	-	-	11	21	-	-	-	-	-	-	-
Diuron	1.9	3.5	350	-	-	-	-	1.9	3.5	-	-	-	-	-	-	-
Endosulfan	0.0085	0.01	210	-	-	-	-	99	190	-	-	-	0.0085	0.01	-	-

Table A-3. Surface Soil Remediation Guideline Values for Residential/Parkland Land Use - All Exposure Pathways

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Receptor	Overall Guideline		Human							Ecological					Other	
Pathway			Direct Soil Contact	Vapour Inhalation				Protection of Domestic Use Aquifer		Direct Soil Contact		Nutrient/ Energy Cycling Check	Protection of Freshwater Aquatic Life		Management Limit	
Soil Type	Fine	Coarse	-	Fine	Fine	Coarse	Coarse	Fine	Coarse	Fine	Coarse		Fine	Coarse	Fine	Coarse
Building Type			-	Basement	Slab	Basement	Slab	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Endrin	0.0075	0.009	10	-	-	-	-	2.4	4.7	-	-	-	0.0075	0.009	-	-
Glyphosate	0.054	0.049	670	-	-	-	-	0.95	1.4	-	-	-	0.054	0.049	-	-
Heptachlor epoxide [g]	0.039	0.010	0.46	0.31	0.21	0.010	0.012	0.039	0.076	-	-	-	BDL	BDL	-	-
Lindane [g]	0.31	0.6	6.7	-	-	-	-	0.31	0.6	-	-	-	BDL	BDL	-	-
Linuron	0.051	0.059	44	-	-	-	-	0.56	1.1	-	-	-	0.051	0.059	-	-
Malathion [g]	0.82	1.3	440	-	-	-	-	0.82	1.3	-	-	-	BDL	BDL	-	-
MCPA [g]	0.02	0.032	11	-	-	-	-	0.02	0.032	-	-	-	BDL	BDL	-	-
Methoxychlor	0.046	0.056	3,500	-	-	-	-	0.046	0.056	-	-	-	-	-	-	-
Metolachlor	0.048	0.055	110	-	-	-	-	1.3	2.4	-	-	-	0.048	0.055	-	-
Metribuzin	0.024	0.028	180	-	-	-	-	7.8	15	-	-	-	0.024	0.028	-	-
Paraquat (as dichloride)	1.1	2.2	22	-	-	-	-	1.1	2.2	-	-	-	-	-	-	-
Parathion [g]	7.2	14	110	-	-	-	-	7.2	14	-	-	-	BDL	BDL	-	-
Phorate	0.075	0.14	4.4	-	-	-	-	0.075	0.14	-	-	-	-	-	-	-
Picloram	0.024	0.022	440	-	-	-	-	0.64	0.94	-	-	-	0.024	0.022	-	-
Simazine	0.033	0.038	29	-	-	-	-	0.14	0.25	-	-	-	0.033	0.038	-	-
Tebuthiuron [g]	2.5	3.7	1,600	-	-	-	-	2.5	3.7	-	-	-	BDL	BDL	-	-
Terbufos	0.08	0.15	1.1	-	-	-	-	0.08	0.15	-	-	-	-	-	-	-
Toxaphene [g]	3.3	4.8	4.8	4,600	3,100	150	170	3.3	6.3	-	-	-	BDL	BDL	-	-

Table A-3. Surface Soil Remediation Guideline Values for Residential/Parkland Land Use - All Exposure Pathways

This table must <u>not</u> be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Tables 1, 3 and 4.
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Receptor	Overall Guideline		Human							Ecological					Other	
Pathway			Direct Soil Contact	Vapour Inhalation				Protection of Domestic Use Aquifer		Direct Soil Contact		Nutrient/ Energy Cycling Check	Protection of Freshwater Aquatic Life		Management Limit	
Soil Type	Fine	Coarse	-	Fine	Fine	Coarse	Coarse	Fine	Coarse	Fine	Coarse		Fine	Coarse	Fine	Coarse
Building Type			-	Basement	Slab	Basement	Slab	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Triallate	0.0077	**0.0092**	290	-	-	-	-	16	31	-	-	-	0.0077	0.0092	-	-
Trifluarin	0.038	**0.045**	110	-	-	-	-	35	67	-	-	-	0.038	0.045	-	-
Other Organics																
Aniline [F]	0.36	**0.6**	160	720	640	34	26	0.36	0.6	-	-	-	BDL	BDL	-	-
Bis(2-ethyl-hexyl)phthalate	34	**41**	1,000	NGR	NGR	NGR	NGR	3,600	7,000	-	-	-	34	41	-	-
Dibutyl phthalate	0.54	**0.65**	1,300	22,0000	18,0000	9,200	7,400	70	130	-	-	-	0.54	0.65	-	-
Dichlorobenzidine	4.2	**8.1**	130	NGR	NGR	NGR	NGR	4.2	8.1	-	-	-	-	-	-	-
Diisopropanolamine	14	**17**	22,000	-	-	-	-	130	250	360	360	-	14	17	-	-
Ethylene glycol	60	**62**	73,000	NGR	NGR	120,000	86,000	60	68	1,100	1,100	1,700	89	62	-	-
Hexachlorobutadiene	0.026	**0.0067**	210	0.18	0.16	0.0087	0.0067	0.5	0.95	-	-	-	0.026	0.031	-	-
Methylmethacrylate	1.3	**0.10**	1,100	3.4	3.0	0.14	0.10	1.3	1.8	-	-	-	-	-	-	-
MTBE	0.044	**0.046**	380	1.2	1.1	0.065	0.046	0.044	0.062	-	-	-	7.1	6.1	-	-
Nonylphenol + ethoxylates	2.7	**3.3**	-	-	-	-	-	-	-	5.7	5.7	-	2.7	3.3	-	-
Phenol	0.0028	**0.0024**	2,000	14,000	13,000	660	480	1.6	2.3	20	20	-	0.0028	0.0024	-	-
Sulfolane	0.18	**0.21**	350	-	-	-	-	0.18	0.21	210	210	-	24	18	-	-

Table A-3. Surface Soil Remediation Guideline Values for Residential/Parkland Land Use - All Exposure Pathways

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Tables 1, 3 and 4. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Notes:

a. For more information see Guidelines for the Remediation and Disposal of Sulphur Contaminated Solid Wastes (AEP, 1996)

b. For more information see Soil Quality Guidelines for Barite: Environmental Health and Human Health (AENV, 2004)

c. Human health direct soil contact guidelines for carcinogenic PAHs are based on B[a]P Total Potency Equivalents (TPE). TPEs are calculated by multiplying the soil concentration of individual carcinogenic PAHs by a standardized Benzo[a]pyrene Potency Equivalence Factor (PEF) to produce a Benzo[a]pyrene relative potency concentration, and by subsequently summing the relative potency concentrations for the entire PAH mixture. B[a]P PEFs are order of magnitude estimates of carcinogenic potential and are based on the World Health Organization (WHO IPCS, 1998) scheme, as follows:

Carcinogenic PAH Compound	PEF
Benz[a]anthracene	0.1
Benzo(b+j)fluoranthene	0.1
Benzo[k]fluoranthene	0.1
Benzo[ghi]perylene	0.01
Benzo[a]pyrene	1
Chrysene	0.01
Dibenz[a,h]anthracene	1
Indeno[1,2,3-c,d]pyrene	0.1

d. The B[a]P Total Potency Equivalents (TPEs) calculated for specific soil samples using Potency Equivalency Factors (PEFs) should be multiplied by an Uncertainty Factor of 3 when evaluating PAH mixtures associated with creosote or coal tar-type environmental releases, prior to evaluating against the human health direct contact soil remediation guideline.

e. The Index of Additive Cancer Risk (IACR) is calculated by dividing the soil concentration of each carcinogenic PAH by its Protection of Domestic Use Aquifer guideline value to calculate a hazard index for each PAH and subsequently summing the hazard indexes for the entire PAH mixture. For example, the IARC for coarse textured soil would be calculated as follows:

Fine Soil:

$$IACR = \frac{[Benz(a)anthracene]}{1.6\ mg \cdot kg^{-1}} + \frac{[Benzo(b+j)fluoranthene]}{0.74\ mg \cdot kg^{-1}} + \frac{[Benzo(k)fluoranthene]}{0.16\ mg \cdot kg^{-1}} + \frac{[Benzo(g,h,i)perylene]}{32\ mg \cdot kg^{-1}} + \frac{[Benzo(a)pyrene]}{1.7\ mg \cdot kg^{-1}} + \frac{[Chrysene]}{10\ mg \cdot kg^{-1}} + \frac{[Dibenz(a,h)anthracene]}{1.1\ mg \cdot kg^{-1}} + \frac{[Indeno(1,2,3-c,d)pyrene]}{13\ mg \cdot kg^{-1}}$$

Coarse Soil:

$$IACR = \frac{[Benz(a)anthracene]}{3.1 mg \cdot kg^{-1}} + \frac{[Benzo(b+j)fluoranthene]}{1.4\ mg \cdot kg^{-1}} + \frac{[Benzo(k)fluoranthene]}{0.31 mg \cdot kg^{-1}} + \frac{[Benzo(g,h,i)perylene]}{63\ mg \cdot kg^{-1}} + \frac{[Benzo(a)pyrene]}{3.4\ mg \cdot kg^{-1}} + \frac{[Chrysene]}{19\ mg \cdot kg^{-1}} + \frac{[Dibenz(a,h)anthracene]}{2.1\ mg \cdot kg^{-1}} + \frac{[Indeno(1,2,3-c,d)pyrene]}{24\ mg \cdot kg^{-1}}$$

f. Overall guideline value for ecological receptors only.

g. Guideline for protection of aquatic life is below detection limit, groundwater monitoring is required.

h. Expressed as toxic equivalents (TEQs) based on 2,3,7,8-PCDD (See CCME, 1999 and updates)

i. Guideline values adopted directly from CCME (1999 and updates) without change.

BDL - Below detection limit

NGR - no guideline required, calculated value >1,000,000 mg/kg; or for PAH groundwater protection, calculated value results in groundwater concentration greater than solubility

Table A-4. Surface Soil Remediation Guideline Values for Commercial Land Use - All Exposure Pathways

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Tables 1, 3 and 4.
This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Receptor	Overall Guideline		Human						Ecological						Other	
Pathway			Direct Soil Contact	Vapour Inhalation		Protection of Domestic Use Aquifer		Off-Site Migration	Direct Soil Contact		Nutrient/ Energy Cycling Check	Protection of Freshwater Aquatic Life		Off-Site Migration	Management Limit	
Soil Type	Fine	Coarse	-	Fine	Coarse	Fine	Coarse	-	Fine	Coarse		Fine	Coarse	-	Fine	Coarse
Building Type			-	Slab	Slab	-	-	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	mg/kg	mg/kg	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
General and Inorganic Parameters																
pH (in 0.01M $CaCl_2$)	6-8.5	6-8.5	-	-	-	-	-	-	6-8.5	6-8.5	-	-	-	-	-	-
Cyanide (free)	8	8	110	-	-	-	-	-	8	8	-	-	-	-	-	-
Fluoride	2,000	2,000	-	-	-	-	-	-	2,000	2,000	-	-	-	-	-	-
Sulphur (elemental)[a]	500	500	-	-	-	-	-	-	500	500	-	-	-	-	-	-
Metals																
Antimony	40	40	-	-	-	-	-	-	40	40	-	-	-	-	-	-
Arsenic (inorganic)	26	26	26	-	-	-	-	-	26	26	-	-	-	-	-	-
Barium	2,000	2,000	-	-	-	-	-	-	2,000	2,000	-	-	-	-	-	-
Barite-barium[b]	11,000	11,000	11,000	-	-	-	-	-	180,000	180,000	-	-	-	-	-	-
Beryllium	8	8	-	-	-	-	-	-	8	8	-	-	-	-	-	-
Boron (hot water soluble)	2	2	-	-	-	-	-	-	2	2	-	-	-	-	-	-
Cadmium	22	22	49	-	-	-	-	-	22	22	195	-	-	-	-	-
Chromium (hexavalent)	1.4	1.4	-	-	-	-	-	-	1.4	1.4	-	-	-	-	-	-
Chromium (total)	87	87	630	-	-	-	-	-	87	87	-	-	-	-	-	-
Cobalt	300	300	-	-	-	-	-	-	300	300	-	-	-	-	-	-
Copper	91	91	4,000	-	-	-	-	-	91	91	350	-	-	-	-	-
Lead	260	260	260	-	-	-	-	-	600	600	834	-	-	-	-	-
Mercury (inorganic)	24	24	24	-	-	-	-	-	50	50	52	-	-	-	-	-
Molybdenum	40	40	-	-	-	-	-	-	40	40	-	-	-	-	-	-
Nickel	50	50	-	-	-	-	-	-	50	50	182	-	-	-	-	-
Selenium	2.9	2.9	300	-	-	-	-	1,135	2.9	2.9	-	-	-	5	-	-
Silver	40	40	-	-	-	-	-	-	40	40	-	-	-	-	-	-
Thallium	1	1	1	-	-	-	-	-	3.6	3.6	-	-	-	-	-	-

Table A-4. Surface Soil Remediation Guideline Values for Commercial Land Use - All Exposure Pathways

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Tables 1, 3 and 4.
This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a) .

Receptor	Overall Guideline		Human						Ecological						Other	
Pathway			Direct Soil Contact	Vapour Inhalation		Protection of Domestic Use Aquifer		Off-Site Migration	Direct Soil Contact		Nutrient/ Energy Cycling Check	Protection of Freshwater Aquatic Life		Off-Site Migration	Management Limit	
Soil Type	Fine	Coarse	-	Fine	Coarse	Fine	Coarse	-	Fine	Coarse		Fine	Coarse	-	Fine	Coarse
Building Type			-	Slab	Slab	-	-	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	mg/kg	mg/kg	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Tin	300	**300**	-	-	-	-	-	-	300	300	-	-	-	-	-	-
Uranium	33	**33**	33	-	-	-	-	-	2000	2000	-	-	-	-	-	-
Vanadium	130	**130**	-	-	-	-	-	-	130	130	255	-	-	-	-	-
Zinc	360	**360**	-	-	-	-	-	-	360	360	320	-	-	-	-	-
Hydrocarbons																
Benzene	0.046	**0.078**	120	11	0.9	0.046	0.078	1,100	310	180	-	73	1.6	440	-	-
Toluene	0.52	**0.49**	31,000	13,000	1,200	0.52	0.95	290,000	330	250	-	250,000	0.49	1,100	-	-
Ethylbenzene	0.11	**0.21**	13,000	6,500	530	0.11	0.21	120,000	430	300	-	NGR	540	790	-	-
Xylenes	15	**28**	210,000	1,700	140	15	28	NGR	230	350	-	NGR	250	930	-	-
Styrene	0.68	**0.8**	16,000	1,600	120	110	210	150,000	-	-	-	0.68	0.8	-	-	-
F1	320	**270**	19,000	4,500	270	1,100	2,200	30,000	320	320	-	30,000	1,300	3,000	800	700
F2	260	**260**	10,000	23,000	1,500	1,500	2,900	30,000	260	260	-	30,000	520	2,100	1,000	1,000
F3	2,500	**1,700**	23,000	-	-	-	-	30,000	2,500	1,700	-	-	-	4,300	3,500	2,500
F4	6,600	**3,300**	30,000	-	-	-	-	30,000	6,600	3,300	-	-	-	30,000	10,000	10,000
Acenapthene	0.32	**0.38**	8,000	770,000	43,000	NGR	NGR	75,000	-	-	-	0.32	0.38	-	-	-
Acenaphthylene	5.0	**6.0**	-	-	-	-	-	-	-	-	-	5.0	6.0	-	-	-
Anthracene	0.0046	**0.0056**	37,000	NGR	NGR	NGR	NGR	350,000	32	32	-	0.0046	0.0056	36	-	-
Fluoranthene	0.032	**0.039**	5,300	NGR	NGR	NGR	NGR	50,000	180	180	-	0.032	0.039	720	-	-
Fluorene	0.29	**0.34**	4,100	NGR	91,000	NGR	NGR	39,000	-	-	-	0.29	0.34	-	-	-
Naphthalene	0.016	**0.018**	2,800	370	25	28	53	26,000	-	-	-	0.016	0.018	-	-	-
Phenanthrene	0.051	**0.061**	-	-	-	-	-	-	-	-	-	0.051	0.061	-	-	-
Pyrene	0.034	**0.040**	3,200	NGR	NGR	NGR	NGR	30,000	-	-	-	0.034	0.040	-	-	-
Carcinogenic PAHs (as B(a)P TPE)[c]	IARC<1.0 [c]	**IARC<1.0 [e]**	8.0 [d]	NGR	NGR	IARC<1.0 [c]	IARC<1.0 [c]	75	-	-	-	-	-	-	-	-
Benz[a]anthracene [f]	0.070	**0.083**	-	-	-	1.6	3.1	-	-	-	-	0.070	0.083	-	-	-

Table A-4. Surface Soil Remediation Guideline Values for Commercial Land Use - All Exposure Pathways

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Tables 1, 3 and 4.
This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Receptor	Overall Guideline		Human						Ecological						Other	
Pathway			Direct Soil Contact	Vapour Inhalation		Protection of Domestic Use Aquifer		Off-Site Migration	Direct Soil Contact		Nutrient/ Energy Cycling Check	Protection of Freshwater Aquatic Life		Off-Site Migration	Management Limit	
Soil Type	Fine	Coarse	-	Fine	Coarse	Fine	Coarse	-	Fine	Coarse		Fine	Coarse	-	Fine	Coarse
Building Type			-	Slab	Slab	-	-	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	mg/kg	mg/kg	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Benzo[b+j]fluoranthene	-	-	-	-	-	0.74	1.4	-	-	-	-	NGR	NGR	-	-	-
Benzo[k]fluoranthene	-	-	-	-	-	0.16	0.31	-	-	-	-	NGR	NGR	-	-	-
Benzo[g,h,i]perylene	-	-	-	-	-	32	63	-	-	-	-	NGR	NGR	-	-	-
Benzo[a]pyrene [f]	0.70	0.77	-	-	-	1.7	3.4	-	72	72	-	0.70	0.77	290	-	-
Chrysene	-	-	-	-	-	10	19	-	-	-	-	NGR	NGR	-	-	-
Dibenz[a,h]anthracene [f]	7.4	8.4	-	-	-	1.1	2.1	-	-	-	-	7.4	8.4	-	-	-
Indeno[1,2,3-c,d]pyrene	-	-	-	-	-	13	24	-	-	-	-	NGR	NGR	-	-	-
Chlorinated Aliphatics																
Vinyl chloride	0.014	0.0043	110	0.055	0.0043	0.014	0.02	1,000	-	-	-	-	-	-	-	-
1,1-Dichloroethene	0.15	0.24	2,900	3.1	0.27	0.15	0.24	27,000	-	-	-	-	-	-	-	-
Trichloroethene (Trichloroethylene, TCE)	0.054	0.081	54	1.9	0.15	0.054	0.093	630	50	50	-	0.72	0.081	43	-	-
Tetrachloroethene (Tetrachloroethylene, Perchloroethylene, PCE)	0.69	0.77	810	26	2	0.77	1.4	7,600	-	-	-	0.69	0.77	-	-	-
1,2-Dichloroethane	0.025	0.033	4,200	0.37	0.033	0.025	0.041	40,000	-	-	-	0.12	0.12	-	-	-
Dichloromethane (Methylene chloride)	0.1	0.095	1,500	110	9.0	0.21	0.32	14,000	-	-	-	0.1	0.095	-	-	-
Trichloromethane (Chloroform)	0.0029	0.003	330	0.15	0.014	0.62	1.0	3,100	-	-	-	0.0029	0.003	-	-	-
Tetrachloromethane (Carbon tetrachloride)	0.059	0.0068	40	0.09	0.0068	0.092	0.16	380	-	-	-	0.059	0.062	-	-	-
Dibromochloromethane	0.91	1.5	1,200	76	2.5	0.91	1.5	11,000	-	-	-	-	-	-	-	-
Chlorinated Aromatics																
Chlorobenzene [g]	0.61	0.22	25,000	2.7	0.22	0.61	1.1	230,000	-	-	-	BDL	BDL	-	-	-
1,2-Dichlorobenzene [g]	0.097	0.18	25,000	1,700	130	0.097	0.18	230,000	-	-	-	BDL	BDL	-	-	-
1,4-Dichlorobenzene	0.051	0.098	6,200	100	8	0.051	0.098	59,000	-	-	-	0.32	0.38	-	-	-

Table A-4. Surface Soil Remediation Guideline Values for Commercial Land Use - All Exposure Pathways

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Tables 1, 3 and 4.
This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a) .

Receptor	Overall Guideline		Human						Ecological						Other	
Pathway			Direct Soil Contact	Vapour Inhalation		Protection of Domestic Use Aquifer		Off-Site Migration	Direct Soil Contact		Nutrient/ Energy Cycling Check	Protection of Freshwater Aquatic Life		Off-Site Migration	Management Limit	
Soil Type	Fine	Coarse	-	Fine	Coarse	Fine	Coarse	-	Fine	Coarse		Fine	Coarse	-	Fine	Coarse
Building Type			-	Slab	Slab	-	-	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	mg/kg	mg/kg	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
1,2,3-Trichlorobenzene	0.26	**0.31**	74	58	2.7	1.9	3.6	700	-	-	-	0.26	0.31	-	-	-
1,2,4-Trichlorobenzene	0.78	**0.93**	58	51	2.4	2.0	3.9	540	-	-	-	0.78	0.93	-	-	-
1,3,5-Trichlorobenzene	1.9	**1.3**	69	27	1.3	1.9	3.6	660	-	-	-	-	-	-	-	-
1,2,3,4-Tetrachlorobenzene	0.042	**0.05**	110	190	7.9	3.1	5.9	1,100	-	-	-	0.042	0.05	-	-	-
1,2,3,5-Tetrachlorobenzene	0.37	**0.70**	14	23	1	0.37	0.70	130	-	-	-	-	-	-	-	-
1,2,4,5-Tetrachlorobenzene	0.19	**0.37**	7	12	0.49	0.19	0.37	66	-	-	-	-	-	-	-	-
Pentachlorobenzene	3.7	**4.5**	34	1000	70	24	47	320	-	-	-	3.7	4.5	-	-	-
Hexachlorobenzene	3.6	**6**	27	85	6	3.6	7	260	-	-	-	-	-	-	-	-
2,4-Dichlorophenol	0.0029	**0.0034**	3,300	NGR	57,000	0.018	0.034	31,000	-	-	-	0.0029	0.0034	-	-	-
2,4,6-Trichlorophenol	0.19	**0.37**	400	71,000	3,300	0.19	0.37	3,700	-	-	-	0.42	0.5	-	-	-
2,3,4,6-Tetrachlorophenol	0.039	**0.047**	340	110,000	4,400	0.16	0.31	3,000	-	-	-	0.039	0.047	-	-	-
Pentachlorophenol	0.024	**0.029**	340	NGR	950,000	6	12	3,200	28	28	-	0.024	0.029	160	-	-
Dioxins & Furans [b,i]	0.000004	**0.000004**	0.000004	-	-	-	-	0.000004	-	-	-	-	-	-	-	-
PCBs	33	**33**	33	-	-	-	-	310	33	33	-	-	-	470	-	-
Pesticides																
Aldicarb [g]	0.041	**0.065**	34	-	-	0.041	0.065	320	-	-	-	BDL	BDL	-	-	-
Aldrin	5.1	**5.1**	5.1	-	-	5.9	11	49	-	-	-	6.1	7.4	-	-	-
Atrazine and metabolites	0.0088	**0.01**	17	-	-	0.10	0.19	160	-	-	-	0.0088	0.01	-	-	-
Azniphos-methyl	0.41	**0.75**	84	-	-	0.41	0.75	790	-	-	-	-	-	-	-	-
Bendiocarb	0.14	**0.21**	130	-	-	0.14	0.21	1,300	-	-	-	-	-	-	-	-
Bromoxynil	0.044	**0.052**	17	-	-	0.18	0.35	160	-	-	-	0.044	0.052	-	-	-
Carbaryl [g]	1.9	**3.6**	340	-	-	1.9	3.6	3,200	-	-	-	BDL	BDL	-	-	-
Carbofuran [g]	0.68	**1.2**	340	-	-	0.68	1.2	3,200	-	-	-	BDL	BDL	-	-	-
Chlorothalonil	0.0084	**0.01**	500	-	-	27	53	4,800	-	-	-	0.0084	0.01	-	-	-

Table A-4. Surface Soil Remediation Guideline Values for Commercial Land Use - All Exposure Pathways

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Tables 1, 3 and 4.
This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Receptor	Overall Guideline		Human						Ecological						Other	
Pathway			Direct Soil Contact	Vapour Inhalation		Protection of Domestic Use Aquifer		Off-Site Migration	Direct Soil Contact		Nutrient/ Energy Cycling Check	Protection of Freshwater Aquatic Life		Off-Site Migration	Management Limit	
Soil Type	Fine	Coarse	-	Fine	Coarse	Fine	Coarse	-	Fine	Coarse		Fine	Coarse	-	Fine	Coarse
Building Type			-	Slab	Slab	-	-	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	mg/kg	mg/kg	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Chlorpyrifos [g]	49	95	340	-	-	49	95	3,200	-	-	-	BDL	BDL	-	-	-
Cyanazine [g]	0.12	0.21	44	-	-	0.12	0.21	410	-	-	-	BDL	BDL	-	-	-
2,4-D [g]	0.43	0.67	340	-	-	0.43	0.67	3,200	-	-	-	BDL	BDL	-	-	-
DDT	0.015	0.018	340	-	-	5,900	11,000	3,200	12	12	547	0.015	0.018	170	-	-
Diazinon	2.2	4.2	67	-	-	2.2	4.2	630	-	-	-	-	-	-	-	-
Dicamba [g]	0.5	0.79	420	-	-	0.5	0.79	4,000	-	-	-	BDL	BDL	-	-	-
Dichlofop-methyl	2	2.4	34	-	-	12	24	320	-	-	-	2	2.4	-	-	-
Dieldrin	0.011	0.014	5.1	-	-	0.59	1.1	49	-	-	-	0.011	0.014	-	-	-
Dimethoate	0.0058	0.0055	67	-	-	0.077	0.12	630	-	-	-	0.0058	0.0055	-	-	-
Dinoseb [g]	2.8	5.5	34	-	-	2.8	5.5	320	-	-	-	BDL	BDL	-	-	-
Diquat	11	21	270	-	-	11	21	2,500	-	-	-	-	-	-	-	-
Diuron	1.9	3.5	520	-	-	1.9	3.5	4,900	-	-	-	-	-	-	-	-
Endosulfan	0.0085	0.01	320	-	-	99	190	3,000	-	-	-	0.0085	0.01	-	-	-
Endrin	0.0075	0.009	15	-	-	2.4	4.7	150	-	-	-	0.0075	0.009	-	-	-
Glyphosate	0.054	0.049	1,000	-	-	0.95	1.4	9,500	-	-	-	0.054	0.049	-	-	-
Heptachlor epoxide [g]	0.039	0.076	0.69	2.4	0.094	0.039	0.076	6.5	-	-	-	BDL	BDL	-	-	-
Lindane [g]	0.31	0.6	10	-	-	0.31	0.6	95	-	-	-	BDL	BDL	-	-	-
Linuron	0.051	0.059	67	-	-	0.56	1.1	630	-	-	-	0.051	0.059	-	-	-
Malathion [g]	0.82	1.3	670	-	-	0.82	1.3	6,300	-	-	-	BDL	BDL	-	-	-
MCPA [g]	0.02	0.032	17	-	-	0.02	0.032	160	-	-	-	BDL	BDL	-	-	-
Methoxychlor	0.046	0.056	5,300	-	-	5,700	11,000	50,000	-	-	-	0.046	0.056	-	-	-
Metolachlor	0.048	0.055	170	-	-	1.3	2.4	1,600	-	-	-	0.048	0.055	-	-	-
Metribuzin	0.024	0.028	280	-	-	7.8	15	2,600	-	-	-	0.024	0.028	-	-	-
Paraquat (as dichloride)	1.1	2.2	34	-	-	1.1	2.2	320	-	-	-	-	-	-	-	-

Table A-4. Surface Soil Remediation Guideline Values for Commercial Land Use - All Exposure Pathways

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Tables 1, 3 and 4.
This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Receptor	Overall Guideline		Human						Ecological						Other	
Pathway			Direct Soil Contact	Vapour Inhalation		Protection of Domestic Use Aquifer		Off-Site Migration	Direct Soil Contact		Nutrient/ Energy Cycling Check	Protection of Freshwater Aquatic Life		Off-Site Migration	Management Limit	
Soil Type	Fine	Coarse	-	Fine	Coarse	Fine	Coarse	-	Fine	Coarse		Fine	Coarse	-	Fine	Coarse
Building Type			-	Slab	Slab	-	-	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	mg/kg	mg/kg	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Parathion [g]	7.2	14	170	-	-	7.2	14	1,600	-	-	-	BDL	BDL	-	-	-
Phorate	0.075	0.14	6.7	-	-	0.075	0.14	63	-	-	-	-	-	-	-	-
Picloram	0.024	0.022	670	-	-	0.64	0.94	6,300	-	-	-	0.024	0.022	-	-	-
Simazine	0.033	0.038	44	-	-	0.14	0.25	410	-	-	-	0.033	0.038	-	-	-
Tebuthiuron [g]	2.5	3.7	2,400	-	-	2.5	3.7	22,000	-	-	-	BDL	BDL	-	-	-
Terbufos	0.08	0.15	1.7	-	-	0.08	0.15	16	-	-	-	-	-	-	-	-
Toxaphene [g]	3.3	6.3	7.3	36,000	1,400	3.3	6.3	69	-	-	-	BDL	BDL	-	-	-
Triallate	0.0077	0.0092	440	-	-	16	31	4,100	-	-	-	0.0077	0.0092	-	-	-
Trifluarin	0.038	0.045	160	-	-	35	67	1,500	-	-	-	0.038	0.045	-	-	-
Other Organics																
Aniline [g]	0.36	0.6	240	4500	300	0.36	0.6	2,200	-	-	-	BDL	BDL	-	-	-
Bis(2-ethyl-hexyl)phthalate	34	41	1,500	NGR	NGR	3,600	7,000	14,000	-	-	-	34	41	-	-	-
Dibutyl phthalate	0.54	0.65	1,900	NGR	82,000	70	130	19,000	-	-	-	0.54	0.65	-	-	-
Dichlorobenzidine	4.2	8.1	190	NGR	NGR	4.2	8.1	1,800	-	-	-	-	-	-	-	-
Diisopropanolamine	14	17	33,000	-	-	130	250	310,000	750	750	-	14	17	5,100	-	-
Ethylene glycol	60	62	110,000	NGR	NGR	60	68	NGR	1,800	1,800	2,000	89	62	16,000	-	-
Hexachlorobutadiene	0.026	0.031	320	1.2	0.078	0.5	0.95	3,000	-	-	-	0.026	0.031	-	-	-
Methylmethacrylate	1.3	1.3	1,700	20	1.3	1.3	1.8	16,000	-	-	-	-	-	-	-	-
MTBE	0.044	0.062	580	7.4	0.57	0.044	0.062	5,400	-	-	-	7.1	6.1	-	-	-
Nonylphenol + ethoxylates	2.7	3.3	-	-	-	-	-	-	14	14	-	2.7	3.3	82	-	-
Phenol	0.0028	0.0024	3,100	90,000	5,800	1.6	2.3	29,000	130	130	-	0.0028	0.0024	290	-	-
Sulfolane	0.18	0.21	540	-	-	0.18	0.21	5,000	430	430	-	24	18	3,000	-	-

Table A-4. Surface Soil Remediation Guideline Values for Commercial Land Use - All Exposure Pathways

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Tables 1, 3 and 4.
This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Notes:

a. For more information see Guidelines for the Remediation and Disposal of Sulphur Contaminated Solid Wastes (AEP, 1996)

b. For more information see Soil Quality Guidelines for Barite: Environmental Health and Human Health (AENV, 2004)

c. Human health direct soil contact guidelines for carcinogenic PAHs are based on B[a]P Total Potency Equivalents (TPE). TPEs are calculated by multiplying the soil concentration of individual carcinogenic PAHs by a the standardized Benzo[a]pyrene Potency Equivalence Factor (PEF) to produce a Benzo[a]pyrene relative potency concentration, and by subsequently summing the relative potency concentrations for entire PAH mixture. B[a]P PEFs are order of magnitude estimates of carcinogenic potential and are based on the World Health Organization (WHO/IPCS, 1998) scheme, as follows:

Carcinogenic PAH Compound	PEF
Benz[a]anthracene	0.1
Benzo(b+j)fluoranthene	0.1
Benzo[k]fluoranthene	0.1
Benzo[ghi]perylene	0.01
Benzo[a]pyrene	1
Chrysene	0.01
Dibenz[a,h]anthracene	1
Indeno[1,2,3-c,d]pyrene	0.1

d. The B[a]P Total Potency Equivalents (TPEs) calculated for specific soil samples using Potency Equivalency Factors (PEFs) should be multiplied by an Uncertainty Factor of 3 when evaluating PAH mixtures associated with creosote or coal tar-type environmental releases, prior to evaluating against the human health direct contact soil remediation guideline.

e. The Index of Additive Cancer Risk (IACR) is calculated by dividing the soil concentration of each carcinogenic PAH by its Protection of Domestic Use Aquifer guideline value to calculate a hazard a hazard index for each PAH and subsequently summing the hazard indexes for the entire PAH mixture, as follows:

Fine Soils:

$$IACR = \frac{[Benz(a)anthracene]}{1.6\ mg \cdot kg^{-1}} + \frac{[Benzo(b+j)fluoranthene]}{0.74\ mg \cdot kg^{-1}} + \frac{[Benzo(k)fluoranthene]}{0.16\ mg \cdot kg^{-1}} + \frac{[Benzo(g,h,i)perylene]}{32\ mg \cdot kg^{-1}} + \frac{[Benzo(a)pyrene]}{1.7\ mg \cdot kg^{-1}} + \frac{[Chrysene]}{10\ mg \cdot kg^{-1}} + \frac{[Dibenz(a,h)anthracene]}{1.1\ mg \cdot kg^{-1}} + \frac{[Indeno(1,2,3-c,d)pyrene]}{13\ mg \cdot kg^{-1}}$$

Coarse Soils:

$$IACR = \frac{[Benz(a)anthracene]}{3.1 mg \cdot kg^{-1}} + \frac{[Benzo(b+j)fluoranthene]}{1.4\ mg \cdot kg^{-1}} + \frac{[Benzo(k)fluoranthene]}{0.31 mg \cdot kg^{-1}} + \frac{[Benzo(g,h,i)perylene]}{63 mg \cdot kg^{-1}} + \frac{[Benzo(a)pyrene]}{3.4\ mg \cdot kg^{-1}} + \frac{[Chrysene]}{19 mg \cdot kg^{-1}} + \frac{[Dibenz(a,h)anthracene]}{2.1\ mg \cdot kg^{-1}} + \frac{[Indeno(1,2,3-c,d)pyrene]}{24\ mg \cdot kg^{-1}}$$

f. Overall guideline value for ecological receptors only.

g. Guideline for protection of aquatic life is below detection limit, groundwater monitoring is required.

h. Expressed as toxic equivalents (TEQs) based on 2,3,7,8-PCDD (See CCME, 1999 and updates)

i. Guideline values adopted directly from CCME (1999 and updates) without change.

BDL - Below detection limit

NGR - no guideline required, calculated value >1,000,000 mg/kg; or for PAH groundwater protection, calculated value results in groundwater concentration greater than solubility

Table A-5. Surface Soil Remediation Guideline Values for Industrial Land Use - All Exposure Pathways

This table must <u>not</u> be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Tables 1, 3 and 4.
This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Receptor	Overall Guideline		Human						Ecological						Other	
Pathway			Direct Soil Contact	Vapour Inhalation		Protection of Domestic Use Aquifer		Off-Site Migration	Direct Soil Contact		Nutrient/ Energy Cycling Check	Protection of Freshwater Aquatic Life		Off-Site Migration	Management Limit	
Soil Type	Fine	Coarse	-	Fine	Coarse	Fine	Coarse	-	Fine	Coarse		Fine	Coarse	-	Fine	Coarse
Building Type			-	Slab	Slab	-	-	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
General and Inorganic Parameters																
pH (in 0.01M $CaCl_2$)	6-8.5	6-8.5	-	-	-	-	-	-	6-8.5	6-8.5	-	-	-	-	-	-
Cyanide (free)	8	8	420	-	-	-	-	-	8	8	-	-	-	-	-	-
Fluoride	2,000	2,000	-	-	-	-	-	-	2,000	2,000	-	-	-	-	-	-
Sulphur (elemental)[a]	500	500	-	-	-	-	-	-	500	500	-	-	-	-	-	-
Metals																
Antimony	40	40	-	-	-	-	-	-	40	40	-	-	-	-	-	-
Arsenic (inorganic)	26	26	26	-	-	-	-	-	26	26	-	-	-	-	-	-
Barium	2,000	2,000	-	-	-	-	-	-	2,000	2,000	-	-	-	-	-	-
Barite-barium[b]	41,000	41,000	41,000	-	-	-	-	-	180,000	180,000	-	-	-	-	-	-
Beryllium	8	8	-	-	-	-	-	-	8	8	-	-	-	-	-	-
Boron (hot water soluble)	2	2	-	-	-	-	-	-	2	2	-	-	-	-	-	-
Cadmium	22	22	2,090	-	-	-	-	-	22	22	195	-	-	-	-	-
Chromium (hexavalent)	1.4	1.4	-	-	-	-	-	-	1.4	1.4	-	-	-	-	-	-
Chromium (total)	87	87	2,300	-	-	-	-	-	87	87	-	-	-	-	-	-
Cobalt	300	300	-	-	-	-	-	-	300	300	-	-	-	-	-	-
Copper	91	91	16,000	-	-	-	-	-	91	91	350	-	-	-	-	-
Lead	600	600	8,200	-	-	-	-	-	600	600	834	-	-	-	-	-
Mercury (inorganic)	50	50	99	-	-	-	-	-	50	50	52	-	-	-	-	-
Molybdenum	40	40	-	-	-	-	-	-	40	40	-	-	-	-	-	-
Nickel	50	50	-	-	-	-	-	-	50	50	182	-	-	-	-	-

Table A-5. Surface Soil Remediation Guideline Values for Industrial Land Use - All Exposure Pathways

This table must <u>not</u> be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Tables 1, 3 and 4.
This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Receptor	Overall Guideline		Human						Ecological						Other	
Pathway			Direct Soil Contact	Vapour Inhalation		Protection of Domestic Use Aquifer		Off-Site Migration	Direct Soil Contact		Nutrient/ Energy Cycling Check	Protection of Freshwater Aquatic Life		Off-Site Migration	Management Limit	
Soil Type	Fine	Coarse	-	Fine	Coarse	Fine	Coarse	-	Fine	Coarse		Fine	Coarse	-	Fine	Coarse
Building Type			-	Slab	Slab	-	-	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Selenium	2.9	2.9	1,135	-	-	-	-	1,135	2.9	2.9	-	-	-	5	-	-
Silver	40	40	-	-	-	-	-	-	40	40	-	-	-	-	-	-
Thallium	1	1	1	-	-	-	-	-	3.6	3.6	-	-	-	-	-	-
Tin	300	300	-	-	-	-	-	-	300	300	-	-	-	-	-	-
Uranium	300	300	510	-	-	-	-	300	2,000	2,000	-	-	-	7,100	-	-
Vanadium	130	130	-	-	-	-	-	-	130	130	255	-	-	-	-	-
Zinc	360	360	-	-	-	-	-	-	360	360	320	-	-	-	-	-
Hydrocarbons																
Benzene	0.046	0.078	120	11	0.9	0.046	0.078	1,100	310	180	-	73	1.6	440	-	-
Toluene	0.52	0.49	350,000	13,000	1,200	0.52	0.95	290,000	330	250	-	250,000	0.49	1,100	-	-
Ethylbenzene	0.11	0.21	120,000	6,500	530	0.11	0.21	120,000	430	300	-	NGR	540	790	-	-
Xylenes	15	28	NGR	1,700	140	15	28	NGR	230	350	-	NGR	250	930	-	-
Styrene	0.68	0.8	150,000	1,600	120	110	210	150,000	-	-	-	0.68	0.8	-	-	-
F1	320	270	30,000	4,500	270	1,100	2,200	30,000	320	320	-	30,000	1,300	3,000	800	700
F2	260	260	30,000	23,000	1,500	1,500	2,900	30,000	260	260	-	30,000	520	2,100	1,000	1,000
F3	2,500	1,700	30,000	-	-	-	-	30,000	2,500	1,700	-	-	-	4,300	3,500	2,500
F4	6,600	3,300	30,000	-	-	-	-	30,000	6,600	3,300	-	-	-	30,000	10,000	10,000
Acenapthene	0.32	0.38	75,000	770,000	43,000	NGR	NGR	75,000	-	-	-	0.32	0.38	-	-	-
Acenaphthylene	5.0	6.0	-	-	-	-	-	-	-	-	-	5.0	6.0	-	-	-
Anthracene	0.0046	0.0056	300,000	NGR	NGR	NGR	NGR	350,000	32	32	-	0.0046	0.0056	36	-	-
Fluoranthene	0.032	0.039	50,000	NGR	NGR	NGR	NGR	50,000	180	180	-	0.032	0.039	720	-	-

Table A-5. Surface Soil Remediation Guideline Values for Industrial Land Use - All Exposure Pathways

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Tables 1, 3 and 4.
This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Receptor	Overall Guideline		Human						Ecological						Other	
Pathway			Direct Soil Contact	Vapour Inhalation		Protection of Domestic Use Aquifer		Off-Site Migration	Direct Soil Contact		Nutrient/ Energy Cycling Check	Protection of Freshwater Aquatic Life		Off-Site Migration	Management Limit	
Soil Type	Fine	Coarse	-	Fine	Coarse	Fine	Coarse	-	Fine	Coarse		Fine	Coarse	-	Fine	Coarse
Building Type			-	Slab	Slab	-	-	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Fluorene	0.29	**0.34**	46,000	NGR	91,000	NGR	NGR	39,000	-	-	-	0.29	0.34	-	-	-
Naphthalene	0.016	**0.018**	34,000	370	25	28	53	26,000	-	-	-	0.016	0.018	-	-	-
Phenanthrene	0.051	**0.061**	-	-	-	-	-	-	-	-	-	0.051	0.061	-	-	-
Pyrene	0.034	**0.040**	34,000	NGR	NGR	NGR	NGR	30,000	-	-	-	0.034	0.040	-	-	-
Carcinogenic PAHs (as B(a)P TPE)[c]	IARC<1.0[e]	**IARC<1.0[e]**	8[d]	NGR	NGR	IARC<1.0[e]	IARC<1.0[e]	75	-	-	-	-	-	-	-	-
Benz[a]anthracene[f]	0.070	**0.083**	-	-	-	1.6	3.1	-	-	-	-	0.070	0.083	-	-	-
Benzo[b+j]fluoranthene	-	-	-	-	-	0.74	1.4	-	-	-	-	NGR	NGR	-	-	-
Benzo[k]fluoranthene	-	-	-	-	-	0.16	0.31	-	-	-	-	NGR	NGR	-	-	-
Benzo[g,h,i]perylene	-	-	-	-	-	32	63	-	-	-	-	NGR	NGR	-	-	-
Benzo[a]pyrene[f]	0.70	**0.77**	-	-	-	1.7	3.4	-	72	72	-	0.70	0.77	290	-	-
Chrysene	-	-	-	-	-	10	19	-	-	-	-	NGR	NGR	-	-	-
Dibenz[a,h]anthracene[f]	7.4	**8.4**	-	-	-	1.1	2.1	-	-	-	-	7.4	8.4	-	-	-
Indeno[1,2,3-c,d]pyrene	-	-	-	-	-	13	24	-	-	-	-	NGR	NGR	-	-	-
Chlorinated Aliphatics																
Vinyl chloride	0.014	**0.0043**	110	0.055	0.0043	0.014	0.02	1,000	-	-	-	-	-	-	-	-
1,1-Dichloroethene	0.15	**0.24**	34,000	3.1	0.27	0.15	0.24	27,000	-	-	-	-	-	-	-	-
Trichloroethene (Trichloroethylene, TCE)	0.054	**0.081**	720	1.9	0.15	0.054	0.093	630	50	50	-	0.72	0.081	43	-	-
Tetrachloroethene (Tetrachloroethylene, Perchloroethylene, PCE)	0.69	**0.77**	9,600	26	2	0.77	1.4	7,600	-	-	-	0.69	0.77	-	-	-
1,2-Dichloroethane	0.025	**0.033**	4,200	0.37	0.033	0.025	0.041	46,000	-	-	-	0.12	0.12	-	-	-
Dichloromethane	0.1	**0.095**	7,300	110	9.0	0.21	0.32	14,000	-	-	-	0.1	0.095	-	-	-

Table A-5. Surface Soil Remediation Guideline Values for Industrial Land Use - All Exposure Pathways

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Tables 1, 3 and 4.
This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Receptor	Overall Guideline		Human						Ecological						Other	
Pathway			Direct Soil Contact	Vapour Inhalation		Protection of Domestic Use Aquifer		Off-Site Migration	Direct Soil Contact		Nutrient/ Energy Cycling Check	Protection of Freshwater Aquatic Life		Off-Site Migration	Management Limit	
Soil Type	Fine	Coarse	-	Fine	Coarse	Fine	Coarse	-	Fine	Coarse		Fine	Coarse	-	Fine	Coarse
Building Type			-	Slab	Slab	-	-	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
(Methylene chloride)																
Trichloromethane (Chloroform)	0.0029	**0.003**	4,400	0.15	0.014	0.62	1.0	3,100	-	-	-	0.0029	0.003	-	-	-
Tetrachloromethane (Carbon tetrachloride)	0.059	**0.0068**	260	0.09	0.0068	0.092	0.16	380	-	-	-	0.059	0.062	-	-	-
Dibromochloromethane	0.91	**1.5**	14,000	76	2.5	0.91	1.5	11,000	-	-	-	-	-	-	-	-
Chlorinated Aromatics																
Chlorobenzene [g]	0.61	**0.22**	300,000	2.7	0.22	0.61	1.1	230,000	-	-	-	BDL	BDL	-	-	-
1,2-Dichlorobenzene [g]	0.097	**0.18**	300,000	1700	130	0.097	0.18	230,000	-	-	-	BDL	BDL	-	-	-
1,4-Dichlorobenzene	0.051	**0.098**	74,000	100	8	0.051	0.098	59,000	-	-	-	0.32	0.38	-	-	-
1,2,3-Trichlorobenzene	0.26	**0.31**	930	58	2.7	1.9	3.6	700	-	-	-	0.26	0.31	-	-	-
1,2,4-Trichlorobenzene	0.78	**0.93**	850	51	2.4	2.0	3.9	540	-	-	-	0.78	0.93	-	-	-
1,3,5-Trichlorobenzene	1.9	**1.3**	920	27	1.3	1.9	3.6	660	-	-	-	-	-	-	-	-
1,2,3,4-Tetrachlorobenzene	0.042	**0.05**	540	190	7.9	3.1	5.9	1,100	-	-	-	0.042	0.05	-	-	-
1,2,3,5-Tetrachlorobenzene	0.37	**0.70**	66	23	0.96	0.37	0.70	130	-	-	-	-	-	-	-	-
1,2,4,5-Tetrachlorobenzene	0.19	**0.37**	34	12	0.49	0.19	0.37	66	-	-	-	-	-	-	-	-
Pentachlorobenzene	3.7	**4.5**	160	1000	70	24	47	320	-	-	-	3.7	4.5	-	-	-
Hexachlorobenzene	3.6	**6**	30	85	6	3.6	7	260	-	-	-	-	-	-	-	-
2,4-Dichlorophenol	0.0029	**0.0034**	16,000	NGR	57,000	0.018	0.034	31,000	-	-	-	0.0029	0.0034	-	-	-
2,4,6-Trichlorophenol	0.19	**0.37**	400	71,000	3,300	0.19	0.37	3,700	-	-	-	0.42	0.5	-	-	-
2,3,4,6-Tetrachlorophenol	0.039	**0.047**	1,500	110,000	4,400	0.16	0.31	3,000	-	-	-	0.039	0.047	-	-	-
Pentachlorophenol	0.024	**0.029**	4,000	NGR	950,000	6	12	3,200	28	28	-	0.024	0.029	160	-	-

Table A-5. Surface Soil Remediation Guideline Values for Industrial Land Use - All Exposure Pathways

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Tables 1, 3 and 4.
This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Receptor	Overall Guideline		Human						Ecological						Other	
Pathway			Direct Soil Contact	Vapour Inhalation		Protection of Domestic Use Aquifer		Off-Site Migration	Direct Soil Contact		Nutrient/ Energy Cycling Check	Protection of Freshwater Aquatic Life		Off-Site Migration	Management Limit	
Soil Type	Fine	Coarse	-	Fine	Coarse	Fine	Coarse	-	Fine	Coarse		Fine	Coarse	-	Fine	Coarse
Building Type			-	Slab	Slab	-	-	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Dioxins & Furans [h,i]	0.000004	0.000004	-	-	-	-	-	0.000004	-	-	-	-	-	-	-	-
PCBs	33	33	160	-	-	-	-	310	33	33	-	-	-	470	-	-
Pesticides																
Aldicarb [g]	0.041	0.065	160	-	-	0.041	0.065	320	-	-	-	BDL	BDL	-	-	-
Aldrin	5.9	7.4	44	-	-	5.9	11	49	-	-	-	6.1	7.4	-	-	-
Atrazine and metabolites	0.0088	0.01	80	-	-	0.10	0.19	160	-	-	-	0.0088	0.01	-	-	-
Azniphos-methyl	0.41	0.75	400	-	-	0.41	0.75	790	-	-	-	-	-	-	-	-
Bendiocarb	0.14	0.21	640	-	-	0.14	0.21	1,300	-	-	-	-	-	-	-	-
Bromoxynil	0.044	0.052	80	-	-	0.18	0.35	160	-	-	-	0.044	0.052	-	-	-
Carbaryl [g]	1.9	3.6	1,600	-	-	1.9	3.6	3,200	-	-	-	BDL	BDL	-	-	-
Carbofuran [g]	0.68	1.2	1,600	-	-	0.68	1.2	3,200	-	-	-	BDL	BDL	-	-	-
Chlorothalonil	0.0084	0.01	2,400	-	-	27	53	4,800	-	-	-	0.0084	0.01	-	-	-
Chlorpyrifos [g]	49	95	1,600	-	-	49	95	3,200	-	-	-	BDL	BDL	-	-	-
Cyanazine [g]	0.12	0.21	210	-	-	0.12	0.21	410	-	-	-	BDL	BDL	-	-	-
2,4-D [g]	0.43	0.67	1,600	-	-	0.43	0.67	3,200	-	-	-	BDL	BDL	-	-	-
DDT	0.015	0.018	1,600	-	-	5,900	11,000	3,200	12	12	547	0.015	0.018	170	-	-
Diazinon	2.2	4.2	320	-	-	2.2	4.2	630	-	-	-	-	-	-	-	-
Dicamba [g]	0.5	0.79	2,000	-	-	0.5	0.79	4,000	-	-	-	BDL	BDL	-	-	-
Dichlofop-methyl	2	2.4	160	-	-	12	24	320	-	-	-	2	2.4	-	-	-
Dieldrin	0.011	0.014	44	-	-	0.59	1.1	49	-	-	-	0.011	0.014	-	-	-
Dimethoate	0.0058	0.0055	320	-	-	0.077	0.12	630	-	-	-	0.0058	0.0055	-	-	-

Table A-5. Surface Soil Remediation Guideline Values for Industrial Land Use - All Exposure Pathways

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Tables 1, 3 and 4. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Receptor	Overall Guideline		Human						Ecological						Other	
Pathway			Direct Soil Contact	Vapour Inhalation		Protection of Domestic Use Aquifer		Off-Site Migration	Direct Soil Contact		Nutrient/ Energy Cycling Check	Protection of Freshwater Aquatic Life		Off-Site Migration	Management Limit	
Soil Type	Fine	Coarse	-	Fine	Coarse	Fine	Coarse	-	Fine	Coarse		Fine	Coarse	-	Fine	Coarse
Building Type			-	Slab	Slab	-	-	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Dinoseb [#]	2.8	5.5	160	-	-	2.8	5.5	320	-	-	-	BDL	BDL	-	-	-
Diquat	11	21	1,300	-	-	11	21	2,500	-	-	-	-	-	-	-	-
Diuron	1.9	3.5	2,500	-	-	1.9	3.5	4,900	-	-	-	-	-	-	-	-
Endosulfan	0.0085	0.01	3,000	-	-	99	190	3,000	-	-	-	0.0085	0.01	-	-	-
Endrin	0.0075	0.009	130	-	-	2.4	4.7	150	-	-	-	0.0075	0.009	-	-	-
Glyphosate	0.054	0.049	4,800	-	-	0.95	1.4	9,500	-	-	-	0.054	0.049	-	-	-
Heptachlor epoxide [#]	0.039	0.076	2.8	2.4	0.094	0.039	0.076	6.5	-	-	-	BDL	BDL	-	-	-
Lindane [#]	0.31	0.6	48	-	-	0.31	0.6	95	-	-	-	BDL	BDL	-	-	-
Linuron	0.051	0.059	320	-	-	0.56	1.1	630	-	-	-	0.051	0.059	-	-	-
Malathion [#]	0.82	1.3	3,200	-	-	0.82	1.3	6,300	-	-	-	BDL	BDL	-	-	-
MCPA [#]	0.02	0.032	80	-	-	0.02	0.032	160	-	-	-	BDL	BDL	-	-	-
Methoxychlor	0.046	0.056	50,000	-	-	5,700	11,000	50,000	-	-	-	0.046	0.056	-	-	-
Metolachlor	0.048	0.055	800	-	-	1.3	2.4	1,600	-	-	-	0.048	0.055	-	-	-
Metribuzin	0.024	0.028	1,300	-	-	7.8	15	2,600	-	-	-	0.024	0.028	-	-	-
Paraquat (as dichloride)	1.1	2.2	160	-	-	1.1	2.2	320	-	-	-	-	-	-	-	-
Parathion [#]	7.2	14	800	-	-	7.2	14	1,600	-	-	-	BDL	BDL	-	-	-
Phorate	0.075	0.14	32	-	-	0.075	0.14	63	-	-	-	-	-	-	-	-
Picloram	0.024	0.022	3,200	-	-	0.64	0.94	6,300	-	-	-	0.024	0.022	-	-	-
Simazine	0.033	0.038	210	-	-	0.14	0.25	410	-	-	-	0.033	0.038	-	-	-
Tebuthiuron [#]	2.5	3.7	11,000	-	-	2.5	3.7	22,000	-	-	-	BDL	BDL	-	-	-
Terbufos	0.08	0.15	8	-	-	0.08	0.15	16	-	-	-	-	-	-	-	-

Table A-5. Surface Soil Remediation Guideline Values for Industrial Land Use - All Exposure Pathways

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Tables 1, 3 and 4.
This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Receptor	Overall Guideline		Human						Ecological						Other	
Pathway			Direct Soil Contact	Vapour Inhalation		Protection of Domestic Use Aquifer		Off-Site Migration	Direct Soil Contact		Nutrient/ Energy Cycling Check	Protection of Freshwater Aquatic Life		Off-Site Migration	Management Limit	
Soil Type	Fine	Coarse	-	Fine	Coarse	Fine	Coarse	-	Fine	Coarse		Fine	Coarse	-	Fine	Coarse
Building Type			-	Slab	Slab	-	-	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Toxaphene [g]	3.3	6.3	7.3	36,000	1,400	3.3	6.3	69	-	-	-	BDL	BDL	-	-	-
Triallate	0.0077	0.0092	2,100	-	-	16	31	4,100	-	-	-	0.0077	0.0092	-	-	-
Trifluarin	0.038	0.045	770	-	-	35	67	1,500	-	-	-	0.038	0.045	-	-	-
Other Organics																
Aniline [g]	0.36	0.6	1,100	4,500	300	0.36	0.6	2,200	-	-	-	BDL	BDL	-	-	-
Bis(2-ethyl-hexyl)phthalate	34	41	37,000	NGR	NGR	3,600	7,000	14,000	-	-	-	34	41	-	-	-
Dibutyl phthalate	0.54	0.65	9,600	NGR	82,000	70	130	19,000	-	-	-	0.54	0.65	-	-	-
Dichlorobenzidine	4.2	8.1	190	NGR	NGR	4.2	8.1	1,800	-	-	-	-	-	-	-	-
Diisopropanolamine	14	17	280,000	-	-	130	250	310,000	750	750	-	14	17	5,100	-	-
Ethylene glycol	60	62	530,000	NGR	NGR	60	68	NGR	1,800	1,800	2,000	89	62	16,000	-	-
Hexachlorobutadiene	0.026	0.031	320	1.2	0.078	0.5	0.95	3,000	-	-	-	0.026	0.031	-	-	-
Methylmethacrylate	1.3	1.3	8,000	21	1.3	1.3	1.8	16,000	-	-	-	-	-	-	-	-
MTBE	0.044	0.062	6,800	7.4	0.57	0.044	0.062	5,400	-	-	-	7.1	6.1	-	-	-
Nonylphenol + ethoxylates	2.7	3.3	-	-	-	-	-	-	14	14	-	2.7	3.3	82	-	-
Phenol	0.0028	0.0024	26,000	90,000	5,800	1.6	2.3	29,000	130	130	-	0.0028	0.0024	290	-	-
Sulfolane	0.18	0.21	2,600	-	-	0.18	0.21	5,000	430	430	-	24	18	3,000	-	-

Table A-5. Surface Soil Remediation Guideline Values for Industrial Land Use - All Exposure Pathways

This table must <u>not</u> be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Tables 1, 3 and 4.
This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a) .

Notes:

a. For more information see Guidelines for the Remediation and Disposal of Sulphur Contaminated Solid Wastes (AEP, 1996)

b. For more information see Soil Quality Guidelines for Barite: Environmental Health and Human Health (AENV, 2004)

c. Human health direct soil contact guidelines for carcinogenic PAHs are based on B[a]P Total Potency Equivalents (TPE). TPEs are calculated by multiplying the soil concentration of individual carcinogenic PAHs by a standardized Benzo[a]pyrene Potency Equivalence Factor (PEF) to produce a Benzo[a]pyrene relative potency concentration, and by subsequently summing the relative potency concentrations for the entire PAH mixture. B[a]P PEFs are order of magnitude estimates of carcinogenic potential and are based on the World Health Organization (WHO IPCS, 1998) scheme, as follows:

Carcinogenic PAH Compound	PEF
Benz[a]anthracene	0.1
Benzo(b+j)fluoranthene	0.1
Benzo[k]fluoranthene	0.1
Benzo[ghi]perylene	0.01
Benzo[a]pyrene	1
Chrysene	0.01
Dibenz[a,h]anthracene	1
Indeno[1,2,3-c,d]pyrene	0.1

d. The B[a]P Total Potency Equivalents (TPEs) calculated for specific soil samples using Potency Equivalency Factors (PEFs) should be multiplied by an Uncertainty Factor of 3 when evaluating PAH mixtures associated with creosote or coal tar-type environmental releases, prior to evaluating against the human health direct contact soil remediation guideline.

e. The Index of Additive Cancer Risk (IACR) is calculated by dividing the soil concentration of each carcinogenic PAH by its Protection of Domestic Use Aquifer guideline value to calculate a hazard index for each PAH and subsequently summing the hazard indexes for the entire PAH mixture. For example, the IARC for coarse textured soil would be calculated as follows:

Fine Soil:

$$IACR = \frac{[Benz(a)anthracene]}{1.6\ mg \cdot kg^{-1}} + \frac{[Benzo(b+j)fluoranthene]}{0.74\ mg \cdot kg^{-1}} + \frac{[Benzo(k)fluoranthene]}{0.16\ mg \cdot kg^{-1}} + \frac{[Benzo(g,h,i)perylene]}{32\ mg \cdot kg^{-1}} + \frac{[Benzo(a)pyrene]}{1.7\ mg \cdot kg^{-1}} + \frac{[Chrysene]}{10\ mg \cdot kg^{-1}} + \frac{[Dibenz(a,h)anthracene]}{1.1\ mg \cdot kg^{-1}} + \frac{[Indeno(1,2,3-c,d)pyrene]}{13\ mg \cdot kg^{-1}}$$

Coarse Soil:

$$IACR = \frac{[Benz(a)anthracene]}{3.1 mg \cdot kg^{-1}} + \frac{[Benzo(b+j)fluoranthene]}{1.4\ mg \cdot kg^{-1}} + \frac{[Benzo(k)fluoranthene]}{0.31 mg \cdot kg^{-1}} + \frac{[Benzo(g,h,i)perylene]}{63\ mg \cdot kg^{-1}} + \frac{[Benzo(a)pyrene]}{3.4\ mg \cdot kg^{-1}} + \frac{[Chrysene]}{19\ mg \cdot kg^{-1}} + \frac{[Dibenz(a,h)anthracene]}{2.1\ mg \cdot kg^{-1}} + \frac{[Indeno(1,2,3-c,d)pyrene]}{24\ mg \cdot kg^{-1}}$$

f. Overall guideline value for ecological receptors only.

g. Guideline for protection of aquatic life is below detection limit, groundwater monitoring is required.

h. Expressed as toxic equivalents (TEQs) based on 2,3,7,8-PCDD (See CCME, 1999 and updates)

i. Guideline values adopted directly from CCME (1999 and updates) without change.

BDL - Below detection limit

NGR - no guideline required, calculated value >1,000,000 mg/kg; or for PAH groundwater protection, calculated value results in groundwater concentration greater than solubility.

Table A-6. Subsoil Remediation Guideline Values for Natural Area Land Use - All Exposure Pathways (BTEX and PHC Only)

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Tables 1, 3 and 4.
This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Receptor	Overall Guideline		Human		Ecological									Other	
Pathway			Protection of Domestic Use Aquifer		Direct Soil Contact		Nutrient/ Energy Cycling Check	Livestock Soil and Food Ingestion	Wildlife Soil and Food Ingestion	Protection of Freshwater Aquatic Life		Protection of Wildlife Water		Management Limit	
Soil Type	Fine	Coarse	Fine	Coarse	Fine	Coarse		-	-	Fine	Coarse	Fine	Coarse	Fine	Coarse
Building Type			-	-	-	-	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Benzene	0.046	0.078	0.046	0.078	120	62	-	na	na	73	1.6	15	0.33	-	-
Toluene	0.52	0.49	0.52	0.95	220	150	-	na	na	250,000	0.49	NGR	1,000	-	-
Ethylbenzene	0.11	0.21	0.11	0.21	240	110	-	na	na	NGR	540	NGR	17,000	-	-
Xylenes	15	28	15	28	130	190	-	na	na	NGR	250	NGR	16,000	-	-
F1	420	420	1,100	2,200	420	420	-	na	na	20,000	1,300	NGR	360,000	800	700
F2	300	300	1,500	2,900	300	300	-	na	na	20,000	520	NGR	210,000	1,000	1,000
F3	2,600	600	-	-	2,600	600	-	na	na	-	-	-	-	3,500	2,500
F4	10,000	5,600	-	-	11,200	5,600	-	na	na	-	-	-	-	10,000	10,000

Notes:

na = exposure pathway not applicable to subsoil

NGR - no guideline required, calculated value >1,000,000 mg/kg

Table A-7. Subsoil Remediation Guideline Values for Agricultural Land Use - All Exposure Pathways (BTEX and PHC Only)

This table must <u>not</u> be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Tables 1, 3 and 4.
This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Receptor	Overall Guideline		Human							Ecological													Other	
Pathway			Direct Soil Contact	Vapour Inhalation				Protection of Domestic Use Aquifer		Direct Soil Contact		Nutrient/ Energy Cycling Check	Livestock Soil and Food Ingestion	Wildlife Soil and Food Ingestion	Protection of Freshwater Aquatic Life		Protection of Livestock Water		Protection of Wildlife Water		Protection of Irrigation Water		Management Limit	
Soil Type	Fine	Coarse	-	Fine	Fine	Coarse	Coarse	Fine	Coarse	Fine	Coarse		-	-	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse
Building Type			-	Basement	Slab	Basement	Slab	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	mg/kg	mg/kg	mg/kg	mg/kg	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Benzene	0.046	0.078	78	1.7	1.6	0.10	0.14	0.046	0.078	120	62	-	na	na	73	1.6	0.2	0.21	15	0.33	-	-	-	-
Toluene	0.52	0.49	20,000	2,100	2,000	130	180	0.52	0.95	220	150	-	na	na	250,000	0.49	26	29	NGR	1,000	-	-	-	-
Ethylbenzene	0.11	0.21	8,500	1,000	970	60	86	0.11	0.21	240	110	-	na	na	NGR	540	36	42	NGR	17,000	-	-	-	-
Xylenes	15	16	140,000	280	260	16	23	15	28	130	190	-	na	na	NGR	250	160	180	NGR	16,000	-	-	-	-
F1	420	30	12,000	710	630	30	55	1,100	2,200	420	420	-	na	na	20,000	1,300	6,600	7,300	NGR	360,000	-	-	800	700
F2	300	160	6,800	3,600	3,300	160	290	1,500	2,900	300	300	-	na	na	20,000	520	16,000	19,000	NGR	210,000	-	-	1,000	1,000
F3	2,600	600	15,000	-	-	-	-	-	-	2,600	600	-	na	na	-	-	-	-	-	-	-	-	3,500	2,500
F4	10,000	5,600	21,000	-	-	-	-	-	-	11,200	5,600	-	na	na	-	-	-	-	-	-	-	-	10,000	10,000

Notes:
na = exposure pathway not applicable to subsoil
NGR - no guideline required, calculated value >1,000,000 mg/kg

Table A-8. Subsoil Remediation Guideline Values for Residential/Parkland Land Use - All Exposure Pathways (BTEX and PHC Only)

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Tables 1, 3 and 4.
This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Receptor	Overall Guideline		Human							Ecological					Other	
Pathway			Direct Soil Contact	Vapour Inhalation				Protection of Domestic Use Aquifer		Direct Soil Contact		Nutrient/ Energy Cycling Check	Protection of Freshwater Aquatic Life		Management Limit	
Soil Type	Fine	Coarse	-	Fine	Fine	Coarse	Coarse	Fine	Coarse	Fine	Coarse		Fine	Coarse	Fine	Coarse
Building Type			-	Basement	Slab	Basement	Slab	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	mg/kg	mg/kg	mg/kg	mg/kg	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Benzene	0.046	0.078	78	1.7	1.6	0.10	0.14	0.046	0.078	120	62	-	73	1.6	-	-
Toluene	0.52	0.49	20,000	2,100	2,000	130	180	0.52	0.95	220	150	-	250,000	0.49	-	-
Ethylbenzene	0.11	0.21	8,500	1,000	970	60	86	0.11	0.21	240	110	-	NGR	540	-	-
Xylenes	15	16	140,000	280	260	16	23	15	28	130	190	-	NGR	250	-	-
F1	420	30	12,000	710	630	30	55	1,100	2,200	420	420	-	20,000	1300	800	700
F2	300	160	6,800	3,600	3,300	160	290	1,500	2,900	300	300	-	20,000	520	1,000	1,000
F3	2,600	600	15,000	-	-	-	-	-	-	2,600	600	-	-	-	3,500	2,500
F4	10,000	5,600	21,000	-	-	-	-	-	-	11,200	5,600	-	-	-	10,000	10,000

Notes
na = exposure pathway not applicable to subsoil
NGR - no guideline required, calculated value >1,000,000 mg/kg

Table A-9. Subsoil Remediation Guideline Values for Commercial Land Use - All Exposure Pathways (BTEX and PHC Only)

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Tables 1, 3 and 4.
This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Receptor	Overall Guideline		Human						Ecological						Other	
Pathway			Direct Soil Contact	Vapour Inhalation		Protection of Domestic Use Aquifer		Off-Site Migration	Direct Soil Contact		Nutrient/ Energy Cycling Check	Protection of Freshwater Aquatic Life		Off-Site Migration	Management Limit	
Soil Type	Fine	Coarse	-	Fine	Coarse	Fine	Coarse	-	Fine	Coarse		Fine	Coarse	-	Fine	Coarse
Building Type			-	Slab	Slab	-	-	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	mg/kg	mg/kg	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Benzene	0.046	0.078	120	11	1.2	0.046	0.078	1,100	620	360	-	73	1.6	890	-	-
Toluene	0.52	0.49	31,000	14,000	1,600	0.52	0.95	290,000	660	500	-	250,000	0.49	2,100	-	-
Ethylbenzene	0.11	0.21	13,000	6,700	760	0.11	0.21	120,000	860	600	-	NGR	540	1,600	-	-
Xylenes	15	28	210,000	1,800	210	15	28	NGR	460	700	-	NGR	250	930	-	-
F1	640	440	19,000	4,700	440	1,100	2,200	180,000	640	640	-	20,000	1300	3,000	800	700
F2	520	520	10,000	24,000	2,400	1,500	2,900	97,000	520	520	-	20,000	520	2,100	1,000	1,000
F3	3,500	2,500	23,000	-	-	-	-	210,000	5,000	3,400	-	-	-	4,300	3,500	2,500
F4	10,000	6,600	32,000	-	-	-	-	300,000	13,200	6,600	-	-	-	40,000	10,000	10,000

Notes:
na = exposure pathway not applicable to subsoil
NGR - no guideline required, calculated value >1,000,000 mg/kg

Table A-10. Subsoil Remediation Guideline Values for Industrial Land Use - All Exposure Pathways (BTEX and PHC Only)

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Tables 1, 3 and 4.
This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Receptor	Overall Guideline		Human						Ecological						Other	
Pathway			Direct Soil Contact	Vapour Inhalation		Protection of Domestic Use Aquifer		Off-Site Migration	Direct Soil Contact		Nutrient/ Energy Cycling Check	Protection of Freshwater Aquatic Life		Off-Site Migration	Management Limit	
Soil Type	Fine	Coarse	-	Fine	Coarse	Fine	Coarse	-	Fine	Coarse		Fine	Coarse	-	Fine	Coarse
Building Type			-	Slab	Slab	-	-	-	-	-	-	-	-	-	-	-
Unit	(mg/kg)	(mg/kg)	(mg/kg)	mg/kg	mg/kg	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Benzene	0.046	0.078	120	11	1.2	0.046	0.078	1,100	620	360	-	73	1.6	890	-	-
Toluene	0.52	0.49	350,000	14,000	1,600	0.52	0.95	290,000	660	500	-	250,000	0.49	2,100	-	-
Ethylbenzene	0.11	0.21	120,000	6,700	760	0.11	0.21	120,000	860	600	-	NGR	540	1,600	-	-
Xylenes	15	28	NGR	1,800	210	15	28	NGR	460	700	-	NGR	250	930	-	-
F1	640	440	180,000	4,700	40	1,100	2,200	180,000	640	640	-	20,000	1300	3,000	800	700
F2	520	520	96,000	24,000	2,400	1,500	2,900	97,000	520	520	-	20,000	520	2,100	1,000	1,000
F3	3,500	2,500	210,000	-	-	-	-	210,000	5,000	3,400	-	-	-	4,300	3,500	2,500
F4	10,000	6,600	300,000	-	-	-	-	300,000	13,200	6,600	-	-	-	40,000	10,000	10,000

Notes:
na = exposure pathway not applicable to subsoil
NGR - no guideline required, calculated value >1,000,000 mg/kg

APPENDIX B
GROUNDWATER REMEDIATION GUIDELINES
ALL WATER USES

Appendix B consists of four tables, one for each of the land uses, except that commercial and industrial groundwater guidelines are identical, and separate tables are not required. Each table provides the groundwater remediation guideline for each applicable water use, where available. **Tier 1 guidelines must be chosen from Tables 1 to 4, not from Appendix A or B.** The only exception occurs when a more sensitive land use borders on, or is less than 30m from, the site of interest. Under this condition guidelines for specific exposure pathways on the more sensitive land use must be evaluated and if they are lower than the Tier 1 guideline, they must be applied to the site of interest (See Section 5.1.2 and Figure 1).

The four tables are as follows:

- Table B-1. Groundwater Remediation Guideline Values for Natural Area Land Use
- Table B-2. Groundwater Remediation Guideline Values for Agricultural Land Use
- Table B-3. Groundwater Remediation Guideline Values for Residential/Parkland Use
- Table B-4. Groundwater Remediation Guideline Values for Commercial/Industrial Land Use

Note that the groundwater guidelines protective of inhalation under agricultural or residential/parkland use are based on a building with slab-on-grade construction. These values are protective in all cases of both slab-on-grade and basement construction.

All water uses are applicable at Tier 1. However, it may be possible to exclude or modify certain water uses at Tier 2. The companion Tier 2 document (AENV, 2008a) should be consulted for further information. The information in the tables in this appendix will assist in determining whether a Tier 2 approach for groundwater is likely to be useful at a given site.

Table B-1. Groundwater Remediation Guideline Values for Natural Areas - All Water Uses

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Table 2. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Water Use	Lowest Guideline		Potable GW	Eco Soil Contact		Aquatic Life		Wildlife Watering	
Soil Type	Fine	Coarse	All	Fine	Coarse	Fine	Coarse	Fine	Coarse
Unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
General and Inorganic Parameters									
pH	6.5-8.5	6.5-8.5	6.5-8.5	-	-	6.5-9	6.5-9	-	-
Ammonia	see note d	see note d	-	-	-	see note d	see note d	-	-
Chloride	230	230	250	-	-	230	230	-	-
Cyanide	0.005	0.005	0.2	-	-	0.005	0.005	-	-
Fluoride	0.12	0.12	1.5	-	-	0.12	0.12	-	-
Nitrate	13	13	45	-	-	13	13	-	-
Nitrite (as nitrogen)	0.06	0.06	1.0	-	-	0.06	0.06	-	-
Sodium	200	200	200	-	-	-	-	-	-
Sulphate	500	500	500	-	-	-	-	-	-
Sulphide (as H_2S)	0.002	0.002	0.05	-	-	0.002	0.002	-	-
Total Dissolved Solids (TDS)	500	500	500	-	-	-	-	-	-
Metals									
Aluminum	see note d	see note d	-	-	-	see note d	see note d	-	-
Antimony	0.006	0.006	0.006	-	-	-	-	-	-
Arsenic	0.005	0.005	0.01	-	-	0.005	0.005	-	-
Barium	1	1	1	-	-	-	-	-	-
Boron	5	5	5	-	-	-	-	-	-
Bromate	0.01	0.01	0.01	-	-	-	-	-	-
Cadmium	See note e	See note e	0.005	-	-	see note d	see note d	-	-
Chromium (Total)	See note e	See note e	0.05	-	-	see note d	see note d	-	-
Copper	See note e	See note e	1	-	-	see note d	see note d	-	-
Iron	0.3	0.3	0.3	-	-	0.3	0.3	-	-
Lead	See note e	See note e	0.01	-	-	see note d	see note d	-	-
Manganese	0.05	0.05	0.05	-	-	-	-	-	-
Mercury	See note e	See note e	0.001	-	-	see note d	see note d	-	-
Nickel	see note d	see note d				see note d	see note d		
Selenium	0.001	0.001	0.01	-	-	0.001	0.001	-	-

Table B-1. Groundwater Remediation Guideline Values for Natural Areas - All Water Uses

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Table 2. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Water Use	Lowest Guideline		Potable GW	Eco Soil Contact		Aquatic Life		Wildlife Watering	
Soil Type	**Fine**	**Coarse**	**All**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**
Unit	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**
Silver	see note d	see note d	-	-	-	see note d	see note d	-	-
Uranium	0.02	0.02	0.02	-	-	-	-	-	-
Zinc	0.03	0.03	5	-	-	0.03	0.03	-	-
Hydrocarbons									
Benzene	0.005	0.005	0.005	100	61	33	0.69	6.8	0.14
Toluene	0.024	0.024	0.024	82	59	NGR	0.083	NGR	180
Ethylbenzene	0.0024	0.0024	0.0024	42	20	NGR	41	NGR	NGR
Xylenes	0.3	0.3	0.3	21	31	NGR	18	NGR	NGR
Styrene	0.072	0.072	2.8	-	-	0.072	0.072	-	-
F1	2.2	2.2	2.2	6.5	7.1	NGR	9.8	NGR	NGR
F2	1.1	1.1	1.1	1.8	1.8	NGR	1.3	NGR	NGR
Acenapthene	0.0058	0.0058	1.4	-	-	0.0058	0.0058	NGR	NGR
Acenaphthylene	0.046	0.046	-	-	-	0.046	0.046	-	-
Anthracene	0.000012	0.000012	NGR	0.025	0.025	0.000012	0.000012	NGR	NGR
Fluoranthene	0.00004	0.00004	NGR	0.24	0.24	0.00004	0.00004	NGR	NGR
Fluorene	0.003	0.003	0.94	-	-	0.003	0.003	NGR	NGR
Naphthalene	0.0011	0.0011	0.47	-	-	0.0011	0.0011	NGR	NGR
Phenanthrene	0.0004	0.0004	-	-	-	0.0004	0.0004	NGR	NGR
Pyrene	0.000025	0.000025	0.71	-	-	0.000025	0.000025	NGR	NGR
Carcinogenic PAHs (as B(a)P TPE) [a]	0.00001	0.00001	0.00001	-	-	-	-	-	-
Benz[a]anthracene [b]	0.000018	0.000018	-	-	-	0.000018	0.000018	NGR	NGR
Benzo[b+j]fluoranthene [b]	0.00048	0.00048	-	-	-	0.00048	0.00048	NGR	NGR
Benzo[k]fluoranthene [b]	0.00048	0.00048	-	-	-	0.00048	0.00048	NGR	NGR
Benzo[g,h,i]perylene [b]	0.00021	0.00017	-	-	-	0.00021	0.00017	-	-
Benzo[a]pyrene [b]	0.000017	0.000015	-	0.0018	0.0018	0.000017	0.000015	NGR	NGR
Chrysene [b]	0.0014	0.0014	-	-	-	0.0014	0.0014	NGR	NGR
Dibenz[a,h]anthracene [b]	0.00028	0.00026	-	-	-	0.00028	0.00026	NGR	NGR
Indeno[1,2,3-c,d]pyrene [b]	0.00023	0.00021	-	-	-	0.00023	0.00021	-	-

Table B-1. Groundwater Remediation Guideline Values for Natural Areas - All Water Uses

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Table 2. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Water Use	Lowest Guideline		Potable GW	Eco Soil Contact		Aquatic Life		Wildlife Watering	
Soil Type	Fine	Coarse	All	Fine	Coarse	Fine	Coarse	Fine	Coarse
Unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Halogenated Aliphatics									
Vinyl chloride	0.002	0.002	0.002	-	-	-	-	-	-
1,1-Dichloroethene	0.014	0.014	0.014	-	-	-	-	-	-
Trichloroethene (Trichloroethylene, TCE)	0.005	0.005	0.005	4.4	5	0.27	0.029	-	-
Tetrachloroethene (Tetrachloroethylene, Perchloroethylene, PCE)	0.03	0.03	0.03	-	-	0.11	0.11	-	-
1,2-Dichloroethane	0.005	0.005	0.005	-	-	0.1	0.1	-	-
Dichloromethane (Methylene chloride)	0.05	0.05	0.05	-	-	0.098	0.098	-	-
Trichloromethane (Chloroform)	0.0018	0.0018	0.093	-	-	0.0018	0.0018	-	-
Tetrachloromethane (Carbon tetrachloride)	0.005	0.005	0.005	-	-	0.013	0.013	-	-
Dibromochloromethane	0.19	0.19	0.19	-	-	-	-	-	-
Chlorinated Aromatics									
Chlorobenzene	0.0013	0.0013	0.03	-	-	0.0013	0.0013	-	-
1,2-Dichlorobenzene	0.0007	0.0007	0.003	-	-	0.0007	0.0007	-	-
1,4-Dichlorobenzene	0.001	0.001	0.001	-	-	0.026	0.026	-	-
1,2,3-Trichlorobenzene	0.008	0.008	0.014	-	-	0.008	0.008	-	-
1,2,4-Trichlorobenzene	0.015	0.015	0.015	-	-	0.024	0.024	-	-
1,3,5-Trichlorobenzene	0.014	0.014	0.014	-	-	-	-	-	-
1,2,3,4-Tetrachlorobenzene	0.0018	0.0018	0.032	-	-	0.0018	0.0018	-	-
1,2,3,5-Tetra :hlorobenzene	0.0038	0.0038	0.0038	-	-	-	-	-	-
1,2,4,5-Tetrachlorobenzene	0.002	0.002	0.002	-	-	-	-	-	-
Pentachlorobenzene	0.006	0.006	0.0094	-	-	0.006	0.006	-	-
Hexachlorobenzene	0.00057	0.00057	0.00057	-	-	-	-	-	-
2,4-Dichlorophenol	0.0002	0.0002	0.0003	-	-	0.0002	0.0002	-	-
2,4,6-Trichlorophenol	0.002	0.002	0.002	-	-	0.018	0.018	-	-
2,3,4,6-Tetrachlorophenol	0.001	0.001	0.001	-	-	0.001	0.001	-	-
Pentachlorophenol	0.0005	0.0005	0.03	0.87	0.88	0.0005	0.0005	-	-
Dioxins & Furans[c]	0.00000012	0.00000012	0.00000012	-	-	-	-	-	-

Table B-1. Groundwater Remediation Guideline Values for Natural Areas - All Water Uses

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Table 2. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Water Use	Lowest Guideline		Potable GW	Eco Soil Contact		Aquatic Life		Wildlife Watering	
Soil Type	Fine	Coarse	All	Fine	Coarse	Fine	Coarse	Fine	Coarse
Unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
PCBs	0.0094	0.0094	0.0094	-	-	-	-	-	-
Pesticides									
Aldicarb	0.001	0.001	0.009	-	-	0.001	0.001	-	-
Aldrin	0.0007	0.0007	0.0007	-	-	0.003	0.003	-	-
Atrazine and metabolites	0.0018	0.0018	0.005	-	-	0.0018	0.0018	-	-
Azniphos-methyl	0.00001	0.00001	0.02	-	-	0.00001	0.00001	-	-
Bendiocarb	0.04	0.04	0.04	-	-	-	-	-	-
Bromoxynil	0.005	0.005	0.005	-	-	0.005	0.005	-	-
Carbaryl	0.0002	0.0002	0.09	-	-	0.0002	0.0002	-	-
Carbofuran	0.0018	0.0018	0.09	-	-	0.0018	0.0018	-	-
Chlorothalonil	0.00018	0.00018	0.14	-	-	0.00018	0.00018	-	-
Chlorpyrifos	0.0000035	0.0000035	0.09	-	-	0.0000035	0.0000035	-	-
Cyanazine	0.002	0.002	0.01	-	-	0.002	0.002	-	-
2,4-D	0.004	0.004	0.1	-	-	0.004	0.004	-	-
DDT	0.000001	0.000001	0.093	-	-	0.000001	0.000001	-	-
Diazinon	0.02	0.02	0.02	-	-	-	-	-	-
Dicamba	0.01	0.01	0.12	-	-	0.01	0.01	-	-
Dichlofop-methyl	0.0061	0.0061	0.009	-	-	0.0061	0.0061	-	-
Dieldrin	0.000056	0.000056	0.0007	-	-	0.000056	0.000056	-	-
Dimethoate	0.0062	0.0062	0.02	-	-	0.0062	0.0062	-	-
Dinoseb	0.00005	0.00005	0.01	-	-	0.00005	0.00005	-	-
Diquat	0.07	0.07	0.07	-	-	-	-	-	-
Diuron	0.15	0.15	0.15	-	-	-	-	-	-
Endosulfan	0.00002	0.00002	0.057	-	-	0.00002	0.00002	-	-
Endrin	0.000036	0.000036	0.0028	-	-	0.000036	0.000036	-	-
Glyphosate	0.065	0.065	0.28	-	-	0.065	0.065	-	-
Heptachlor epoxide	0.0000038	0.0000038	0.000052	-	-	0.0000038	0.0000038	-	-
Lindane	0.00001	0.00001	0.0028	-	-	0.00001	0.00001	-	-

Table B-1. Groundwater Remediation Guideline Values for Natural Areas - All Water Uses

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Table 2. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Water Use	Lowest Guideline		Potable GW	Eco Soil Contact		Aquatic Life		Wildlife Watering	
Soil Type	Fine	Coarse	All	Fine	Coarse	Fine	Coarse	Fine	Coarse
Unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Linuron	0.007	0.007	0.019	-	-	0.007	0.007	-	-
Malathion	0.0001	0.0001	0.19	-	-	0.0001	0.0001	-	-
MCPA	0.0026	0.0026	0.0047	-	-	0.0026	0.0026	-	-
Methoxychlor	0.00003	0.00003	0.9	-	-	0.00003	0.00003	-	-
Metolachlor	0.0078	0.0078	0.05	-	-	0.0078	0.0078	-	-
Metribuzin	0.001	0.001	0.08	-	-	0.001	0.001	-	-
Paraquat (as dichloride)	0.01	0.01	0.01	-	-	-	-	-	-
Parathion	0.000013	0.000013	0.05	-	-	0.000013	0.000013	-	-
Phorate	0.002	0.002	0.002	-	-	-	-	-	-
Picloram	0.029	0.029	0.19	-	-	0.029	0.029	-	-
Simazine	0.01	0.01	0.01	-	-	0.01	0.01	-	-
Tebuthiuron	0.0016	0.0016	0.66	-	-	0.0016	0.0016	-	-
Terbufos	0.001	0.001	0.001	-	-	-	-	-	-
Toxaphene	0.0000002	0.0000002	0.00043	-	-	0.0000002	0.0000002	-	-
Triallate	0.00024	0.00024	0.12	-	-	0.00024	0.00024	-	-
Trifluarin	0.0002	0.0002	0.045	-	-	0.0002	0.0002	-	-
Other Organics									
Aniline	0.0022	0.0022	0.066	-	-	0.0022	0.0022	-	-
Bis(2-ethyl-hexyl)phthalate	0.016	0.016	0.41	-	-	0.016	0.016	-	-
Dibutyl phthalate	0.019	0.019	0.59	-	-	0.019	0.019	-	-
Dichlorobenzidine	0.007	0.007	0.007	-	-	-	-	-	-
Diisopropanolamine	1.6	1.6	3.6	160	160	1.6	1.6	-	-
Ethylene glycol	31	31	31	9,200	16,000	190	190	-	-
Hexachlorobutadiene	0.0013	0.0013	0.006	-	-	0.0013	0.0013	-	-
Methylmethacrylate	0.47	0.47	0.47	-	-	-	-	-	-
MTBE	0.015	0.015	0.015	-	-	10	10	-	-
Nitrilotriacetic acid	0.4	0.4	0.4	-	-	-	-	-	-
Nonylphenol + ethoxylates	0.001	0.001	-	0.0081	0.0081	0.001	0.001	-	-

Table B-1. Groundwater Remediation Guideline Values for Natural Areas - All Water Uses

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Table 2. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Water Use	Lowest Guideline		Potable GW	Eco Soil Contact		Aquatic Life		Wildlife Watering	
Soil Type	Fine	Coarse	All	Fine	Coarse	Fine	Coarse	Fine	Coarse
Unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Phenol	0.004	0.004	0.57	110	150	0.004	0.004	-	-
Sulfolane	0.09	0.09	0.09	1,700	2,800	50	50	-	-
Trihalomethanes - total (THMs)	0.1	0.1	0.1	-	-	-	-	-	-

Notes:

a. B[a]P TPE (Total Potency Equivalents) are calculated by multiplying the groundwater concentration of individual carcinogenic PAHs by a standardized Benzo[a]pyrene Potency Equivalence Factor (PEF) to produce a Benzo[a]pyrene relative potency concentration, and by subsequently summing the relative potency concentrations for the entire PAH mixture. B[a]P PEFs are order of magnitude estimates of carcinogenic potential and are based on the World Health Organization (1999) scheme, as follows:

Carcinogenic PAH Compound	PEF
Benz[a]anthracene	0.1
Benzo(b+j)fluoranthene	0.1
Benzo[k]fluoranthene	0.1
Benzo[ghi]perylene	0.01
Benzo[a]pyrene	1
Chrysene	0.01
Dibenz[a,h]anthracene	1
Indeno[1,2,3-c,d]pyrene	0.1

b. For ecological receptors only.

c. Expressed as toxic equivalents (TEQs) based on 2,3,7,8-PCDD (See CCME, 1999 and updates)

d. See Surface Water Quality Guidelines for Use in Alberta (AENV, 1999) for further guidance on aquatic life pathway.

e. Tier 1 guideline = lowest of aquatic life guideline and potable GW guideline.

NGR - no guideline required, calculated value > solubility or >1,000,000 mg/L

Potable GW = protection of groundwater for potable drinking water

Eco Soil Contact = protection of terrestrial plants and soil invertebrates in areas with shallow groundwater

Aquatic Life = protection of groundwater discharging to a surface water body hosting aquatic life

Wildlife Watering = protection of groundwater discharging to a surface water body from which wildlife may drink

Table B-2. Groundwater Remediation Guideline Values for Agricultural Land - All Water Uses

This table must <u>not</u> be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Table 2. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Water Use	Lowest Guideline		Potable	Inhalation		Eco Soil Contact		Aquatic Life		Irrigation	Livestock	Wildlife Watering	
Soil Type	Fine	Coarse	All	Fine	Coarse	Fine	Coarse	Fine	Coarse	All	All	Fine	Coarse
Unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
General and Inorganic Parameters													
pH	6.5-8.5	6.5-8.5	6.5-8.5	-	-	-	-	6.5-9	6.5-9	-	-	-	-
Ammonia	see note d	see note d	-	-	-	-	-	see note d	see note d	-	-	-	-
Chloride	100	100	250	-	-	-	-	230	230	100	-	-	-
Cyanide	0.005	0.005	0.2	-	-	-	-	0.005	0.005	-	-	-	-
Fluoride	0.12	0.12	1.5	-	-	-	-	0.12	0.12	1	1	-	-
Nitrate	13	13	45	-	-	-	-	13	13	-	-	-	-
Nitrate + Nitrite (as nitrogen)	100	100	-	-	-	-	-	-	-	-	100	-	-
Nitrite (as nitrogen)	0.06	0.06	1.0	-	-	-	-	0.06	0.06	-	10	-	-
Sodium	200	200	200	-	-	-	-	-	-	-	-	-	-
Sulphate	500	500	500	-	-	-	-	-	-	-	1000	-	-
Sulphide (as H_2S)	0.002	0.002	0.05	-	-	-	-	0.002	0.002	-	-	-	-
Total Dissolved Solids (TDS)	500	500	500	-	-	-	-	-	-	-	3000	-	-
Metals													
Aluminum	See note e	See note e	-	-	-	-	-	see note d	see note d	5	5	-	-
Antimony	0.006	0.006	0.006	-	-	-	-	-	-	-	-	-	-
Arsenic	0.005	0.005	0.01	-	-	-	-	0.005	0.005	0.1	0.025	-	-
Barium	1	1	1	-	-	-	-	-	-	-	-	-	-
Boron	0.5	0.5	5	-	-	-	-	-	-	0.5	5	-	-
Bromate	0.01	0.01	0.01	-	-	-	-	-	-	-	-	-	-
Cadmium	See note e	See note e	0.005	-	-	-	-	see note d	see note d	0.0051	0.08	-	-
Chromium (Total)	See note e	See note e	0.05	-	-	-	-	see note d	see note d	-	0.05	-	-
Copper	See note e	See note e	1	-	-	-	-	see note d	see note d	0.2	0.5	-	-
Iron	0.3	0.3	0.3	-	-	-	-	0.3	0.3	5	-	-	-
Lead	See note e	See note e	0.01	-	-	-	-	see note d	see note d	0.2	0.1	-	-

Table B-2. Groundwater Remediation Guideline Values for Agricultural Land - All Water Uses

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Table 2. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Water Use	Lowest Guideline		Potable	Inhalation		Eco Soil Contact		Aquatic Life		Irrigation	Livestock	Wildlife Watering	
Soil Type	**Fine**	**Coarse**	**All**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**All**	**All**	**Fine**	**Coarse**
Unit	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**
Manganese	0.05	0.05	0.05	-	-	-	-	-	-	0.2	-	-	-
Mercury	See note e	See note e	0.001	-	-	-	-	see note d	see note d	-	0.003	-	-
Nickel	See note e	See note e	-	-	-	-	-	see note d	see note d	0.2	1	-	-
Selenium	0.001	0.001	0.01	-	-	-	-	0.001	0.001	0.02	0.05	-	-
Silver	See note e	See note e	-	-	-	-	-	see note d	see note d	0.02	0.05	-	-
Uranium	0.01	0.01	0.02	-	-	-	-	-	-	0.01	0.2	-	-
Zinc	0.03	0.03	5	-	-	-	-	0.03	0.03	1	50	-	-
Hydrocarbons													
Benzene	0.005	0.005	0.005	2.8	0.14	100	61	33	0.69	-	0.088	6.8	0.14
Toluene	0.024	0.024	0.024	NGR	74	82	59	NGR	0.083	-	4.9	NGR	180
Ethylbenzene	0.0024	0.0024	0.0024	NGR	16	42	20	NGR	41	-	3.2	NGR	NGR
Xylenes	0.3	0.3	0.3	80	3.9	21	31	NGR	18	-	13	NGR	NGR
Styrene	0.072	0.072	2.8	90	4.3	-	-	0.072	0.072	-	-	-	-
F1	2.2	0.81	2.2	19	0.81	6.5	7.1	NGR	9.8	-	53	NGR	NGR
F2	1.1	1.1	1.1	NGR	1.5	1.8	1.8	NGR	1.3	-	NGR	NGR	NGR
Acenapthene	0.0058	0.0058	1.4	NGR	NGR	-	-	0.0058	0.0058	-	NGR	NGR	NGR
Acenaphthylene	0.046	0.046	-	-	-	-	-	0.046	0.046	-	-	-	-
Anthracene	0.000012	0.000012	NGR	NGR	NGR	0.025	0.025	0.000012	0.000012	-	NGR	NGR	NGR
Fluoranthene	0.00004	0.00004	NGR	NGR	NGR	0.24	0.24	0.00004	0.00004	-	NGR	NGR	NGR
Fluorene	0.003	0.003	0.94	NGR	NGR	-	-	0.003	0.003	-	NGR	NGR	NGR
Naphthalene	0.0011	0.0011	0.47	14	0.6	-	-	0.0011	0.0011	-	NGR	NGR	NGR
Phenanthrene	0.0004	0.0004	-	-	-	-	-	0.0004	0.0004	-	NGR	NGR	NGR
Pyrene	0.000025	0.000025	0.71	NGR	NGR	-	-	0.000025	0.000025	-	NGR	NGR	NGR
Carcinogenic PAHs (as B(a)P TPE) [a]	0.00001	0.00001	0.00001	-	-	-	-	-	-	-	-	-	-
Benz[a]anthracene [b]	0.000018	0.000018	-	-	-	-	-	0.000018	0.000018	-	NGR	NGR	NGR

Table B-2. Groundwater Remediation Guideline Values for Agricultural Land - All Water Uses

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Table 2. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Water Use	Lowest Guideline		Potable	Inhalation		Eco Soil Contact		Aquatic Life		Irrigation	Livestock	Wildlife Watering	
Soil Type	Fine	Coarse	All	Fine	Coarse	Fine	Coarse	Fine	Coarse	All	All	Fine	Coarse
Unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Benzo[b+j]fluoranthene [b]	0.00048	0.00048	-	-	-	-	-	0.00048	0.00048	-	NGR	NGR	NGR
Benzo[k]fluoranthene [b]	0.00048	0.00048	-	-	-	-	-	0.00048	0.00048	-	NGR	NGR	NGR
Benzo[g,h,i]perylene [b]	0.00021	0.00017	-	-	-	-	-	0.00021	0.00017	-	-	-	-
Benzo[a]pyrene [b]	0.000017	0.000015	-	-	-	0.0018	0.0018	0.000017	0.000015	-	NGR	NGR	NGR
Chrysene [b]	0.0014	0.0014	-	-	-	-	-	0.0014	0.0014	-	NGR	NGR	NGR
Dibenz[a,h]anthracene [b]	0.00028	0.00026	-	-	-	-	-	0.00028	0.00026	-	NGR	NGR	NGR
Indeno[1,2,3-c,d]pyrene [b]	0.00023	0.00021	-	-	-	-	-	0.00023	0.00021	-	-	-	-
Halogenated Aliphatics													
Vinyl chloride	0.002	0.0011	0.002	0.018	0.0011	-	-	-	-	-	-	-	-
1,1-Dichloroethene	0.014	0.014	0.014	0.68	0.039	-	-	-	-	-	-	-	-
Trichloroethene (Trichloroethylene, TCE)	0.005	0.005	0.005	0.41	0.02	4.4	5	0.27	0.029	-	0.05	-	-
Tetrachloroethene (Tetrachloroethylene, Perchloroethylene, PCE)	0.03	0.03	0.03	2.3	0.11	-	-	0.11	0.11	-	-	-	-
1,2-Dichloroethane	0.005	0.005	0.005	0.17	0.01	-	-	0.1	0.1	-	0.005	-	-
Dichloromethane (Methylene chloride)	0.05	0.05	0.05	61	3.4	-	-	0.098	0.098	-	0.05	-	-
Trichloromethane (Chloroform)	0.0018	0.0018	0.093	0.05	0.003	-	-	0.0018	0.0018	-	0.1	-	-
Tetrachloromethane (Carbon tetrachloride)	0.005	0.00056	0.005	0.011	0.00056	-	-	0.013	0.013	-	0.005	-	-
Dibromochloromethane	0.1	0.1	0.19	26	1.1	-	-	-	-	-	0.1	-	-
Chlorinated Aromatics													
Chlorobenzene	0.0013	0.0013	0.03	0.3	0.014	-	-	0.0013	0.0013	-	-	-	-
1,2-Dichlorobenzene	0.0007	0.0007	0.003	116	5.4	-	-	0.0007	0.0007	-	-	-	-
1,4-Dichlorobenzene	0.001	0.001	0.001	4.6	0.22	-	-	0.026	0.026	-	-	-	-
1,2,3-Trichlorobenzene	0.008	0.008	0.014	0.8	0.032	-	-	0.008	0.008	-	-	-	-

Table B-2. Groundwater Remediation Guideline Values for Agricultural Land - All Water Uses

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Table 2. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Water Use	Lowest Guideline		Potable	Inhalation		Eco Soil Contact		Aquatic Life		Irrigation	Livestock	Wildlife Watering	
Soil Type	Fine	Coarse	All	Fine	Coarse	Fine	Coarse	Fine	Coarse	All	All	Fine	Coarse
Unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
1,2,4-Trichlorobenzene	0.015	0.015	0.015	0.71	0.028	-	-	0.024	0.024	-	-	-	-
1,3,5-Trichlorobenzene	0.014	0.014	0.014	0.38	0.015	-	-	-	-	-	-	-	-
1,2,3,4-Tetrachlorobenzene	0.0018	0.0018	0.032	NGR	0.14	-	-	0.0018	0.0018	-	-	-	-
1,2,3,5-Tetrachlorobenzene	0.0038	0.0038	0.0038	0.41	0.017	-	-	-	-	-	-	-	-
1,2,4,5-Tetrachlorobenzene	0.002	0.002	0.002	0.21	0.0088	-	-	-	-	-	-	-	-
Pentachlorobenzene	0.006	0.006	0.0094	NGR	0.038	-	-	0.006	0.006	-	-	-	-
Hexachlorobenzene	0.00052	0.00052	0.00057	0.029	0.0012	-	-	-	-	-	0.00052	-	-
2,4-Dichlorophenol	0.0002	0.0002	0.0003	NGR	1500	-	-	0.0002	0.0002	-	-	-	-
2,4,6-Trichlorophenol	0.002	0.002	0.002	NGR	54	-	-	0.018	0.018	-	-	-	-
2,3,4,6-Tetrachlorophenol	0.001	0.001	0.001	NGR	NGR	-	-	0.001	0.001	-	-	-	-
Pentachlorophenol	0.0005	0.0005	0.03	NGR	NGR	0.87	0.88	0.0005	0.0005	-	-	-	-
Dioxins & Furans[c]	0.00000012	0.00000012	1.2E-07	-	-	-	-	-	-	-	-	-	-
PCBs	0.0094	0.0094	0.0094	-	-	-	-	-	-	-	-	-	-
Pesticides													
Aldicarb	0.001	0.001	0.009	-	-	-	-	0.001	0.001	0.055	0.011	-	-
Aldrin	0.0007	0.0007	0.0007	-	-	-	-	0.003	0.003	-	-	-	-
Atrazine and metabolites	0.0018	0.0018	0.005	-	-	-	-	0.0018	0.0018	0.01	0.005	-	-
Azniphos-methyl	0.00001	0.00001	0.02	-	-	-	-	0.00001	0.00001	-	-	-	-
Bendiocarb	0.04	0.04	0.04	-	-	-	-	-	-	-	-	-	-
Bromoxynil	0.00033	0.00033	0005	-	-	-	-	0.005	0.005	0.00033	0.011	-	-
Carbaryl	0.0002	0.0002	0.09	-	-	-	-	0.0002	0.0002	-	1.1	-	-
Carbofuran	0.0018	0.0018	0.09	-	-	-	-	0.0018	0.0018	-	0.045	-	-
Chlorothalonil	0.00018	0.00018	0.14	-	-	-	-	0.00018	0.00018	0.0058	0.17	-	-
Chlorpyrifos	0.0000035	0.0000035	0.09	-	-	-	-	0.0000035	0.0000035	-	0.024	-	-
Cyanazine	0.0005	0.0005	0.01	-	-	-	-	0.002	0.002	0.0005	0.01	-	-

Table B-2. Groundwater Remediation Guideline Values for Agricultural Land - All Water Uses

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Table 2. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Water Use	Lowest Guideline		Potable	Inhalation		Eco Soil Contact		Aquatic Life		Irrigation	Livestock	Wildlife Watering	
Soil Type	Fine	Coarse	All	Fine	Coarse	Fine	Coarse	Fine	Coarse	All	All	Fine	Coarse
Unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
2,4-D	0.004	0.004	0.1	-	-	-	-	0.004	0.004	-	0.1	-	-
DDT	0.000001	0.000001	0.093	-	-	-	-	0.000001	0.000001	-	0.1	-	-
Diazinon	0.02	0.02	0.02	-	-	-	-	-	-	-	-	-	-
Dicamba	0.000006	0.000006	0.12	-	-	-	-	0.01	0.01	0.000006	0.12	-	-
Dichlofop-methyl	0.00018	0.00018	0.009	-	-	-	-	0.0061	0.0061	0.00018	0.009	-	-
Dieldrin	0.000056	0.000056	0.0007	-	-	-	-	0.000056	0.000056	-	-	-	-
Dimethoate	0.003	0.003	0.02	-	-	-	-	0.0062	0.0062	-	0.003	-	-
Dinoseb	0.00005	0.00005	0.01	-	-	-	-	0.00005	0.00005	0.016	0.15	-	-
Diquat	0.07	0.07	0.07	-	-	-	-	-	-	-	-	-	-
Diuron	0.15	0.15	0.15	-	-	-	-	-	-	-	-	-	-
Endosulfan	0.00002	0.00002	0.057	-	-	-	-	0.00002	0.00002	-	-	-	-
Endrin	0.000036	0.000036	0.0028	-	-	-	-	0.000036	0.000036	-	-	-	-
Glyphosate	0.065	0.065	0.28	-	-	-	-	0.065	0.065	-	0.28	-	-
Heptachlor epoxide	0.0000038	0.0000038	0.000052	0.0043	0.00024	-	-	0.0000038	0.0000038	-	-	-	-
Lindane	0.00001	0.00001	0.0028	-	-	-	-	0.00001	0.00001	-	0.004	-	-
Linuron	0.000071	0.000071	0.019	-	-	-	-	0.007	0.007	0.000071	-	-	-
Malathion	0.0001	0.0001	0.19	-	-	-	-	0.0001	0.0001	-	-	-	-
MCPA	0.000025	0.000025	0.0047	-	-	-	-	0.0026	0.0026	0.000025	0.025	-	-
Methoxychlor	0.00003	0.00003	0.9	-	-	-	-	0.00003	0.00003	-	-	-	-
Metolachlor	0.0078	0.0078	0.05	-	-	-	-	0.0078	0.0078	0.028	0.05	-	-
Metribuzin	0.0005	0.0005	0.08	-	-	-	-	0.001	0.001	0.0005	0.08	-	-
Paraquat (as dichloride)	0.01	0.01	0.01	-	-	-	-	-	-	-	-	-	-
Parathion	0.000013	0.000013	0.05	-	-	-	-	0.000013	0.000013	-	-	-	-
Phorate	0.002	0.002	0.002	-	-	-	-	-	-	-	-	-	-
Picloram	0.029	0.029	0.19	-	-	-	-	0.029	0.029	-	0.19	-	-

Table B-2. Groundwater Remediation Guideline Values for Agricultural Land - All Water Uses

This table must <u>not</u> be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Table 2. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Water Use	Lowest Guideline		Potable	Inhalation		Eco Soil Contact		Aquatic Life		Irrigation	Livestock	Wildlife Watering	
Soil Type	**Fine**	**Coarse**	**All**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**All**	**All**	**Fine**	**Coarse**
Unit	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**
Simazine	0.0005	0.0005	0.01	-	-	-	-	0.01	0.01	0.0005	0.01	-	-
Tebuthiuron	0.00027	0.00027	0.66	-	-	-	-	0.0016	0.0016	0.00027	0.13	-	-
Terbufos	0.001	0.001	0.001	-	-	-	-	-	-	-	-	-	-
Toxaphene	0.0000002	0.0000002	0.00043	6.4	0.31	-	-	0.0000002	0.0000002	-	-	-	-
Triallate	0.00024	0.00024	0.12	-	-	-	-	0.00024	0.00024	-	0.23	-	-
Trifluarin	0.0002	0.0002	0.045	-	-	-	-	0.0002	0.0002	-	0.045	-	-
Other Organics													
Aniline	0.0022	0.0022	0.066	1,900	87	-	-	0.0022	0.0022	-	-	-	-
Bis(2-ethyl-hexyl)phthalate	0.016	0.016	0.41	NGR	NGR	-	-	0.016	0.016	-	-	-	-
Dibutyl phthalate	0.019	0.019	0.59	NGR	NGR	-	-	0.019	0.019	-	-	-	-
Dichlorobenzidine	0.007	0.007	0.007	NGR	NGR	-	-	-	-	-	-	-	-
Diisopropanolamine	1.6	1.6	3.6	-	-	160	160	1.6	1.6	2	-	-	-
Ethylene glycol	31	31	31	NGR	NGR	9,200	16,000	190	190	-	-	-	-
Hexachlorobutadiene	0.0013	0.0013	0.006	0.031	0.0013	-	-	0.0013	0.0013	-	-	-	-
Methylmethacrylate	0.47	0.47	0.47	17	0.84	-	-	-	-	-	-	-	-
MTBE	0.015	0.015	0.015	6.1	0.34	-	-	10	10	-	-	-	-
Nitrilotriacetic acid	0.4	0.4	0.4	-	-	-	-	-	-	-	-	-	-
Nonylphenol + ethoxylates	0.001	0.001	-	-	-	0.0081	0.0081	0.001	0.001	-	-	-	-
Phenol	0.002	0.002	0.57	73,000	3,700	110	150	0.004	0.004	-	0.002	-	-
Sulfolane	0.09	0.09	0.09	-	-	1,700	2,800	50	50	0.5	-	-	-
Trihalomethanes - total (THMs)	0.1	0.1	0.1	-	-	-	-	-	-	-	-	-	-

Table B-2. Groundwater Remediation Guideline Values for Agricultural Land - All Water Uses

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Table 2. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Notes:

a. B[a]P TPE (Total Potency Equivalents) are calculated by multiplying the groundwater concentration of individual carcinogenic PAHs by a standardized Benzo[a]pyrene Potency Equivalence Factor (PEF) to produce a Benzo[a]pyrene relative potency concentration, and by subsequently summing the relative potency concentrations for the entire PAH mixture. B[a]P PEFs are order of magnitude estimates of carcinogenic potential and are based on the World Health Organization (1999) scheme, as follow:

Carcinogenic PAH Compound	PEF
Benz[a]anthracene	0.1
Benzo(b+j)fluoranthene	0.1
Benzo[k]fluoranthene	0.1
Benzo[ghi]perylene	0.01
Benzo[a]pyrene	1
Chrysene	0.01
Dibenz[a,h]anthracene	1
Indeno[1,2,3-c,d]pyrene	0.1

b. For ecological receptors only.

c. Expressed as toxic equivalents (TEQs) based on 2,3,7,8-PCDD (See CCME, 1999 and updates)

d. See Surface Water Quality Guidelines for Use in Alberta (AENV, 1999) for further guidance on aquatic life pathway.

e. Tier 1 guideline = lowest of aquatic life guideline and all other guidelines.

NGR - no guideline required, calculated value > solubility or >1,000,000 mg/L

Potable GW = protection of groundwater for potable drinking water

Inhalation = protection of volatilization from groundwater and migration into indoor air

Eco Soil Contact = protection of terrestrial plants and soil invertebrates in areas with shallow groundwater

Aquatic Life = protection of groundwater discharging to a surface water body hosting aquatic life

Irrigation = protection of a potential irrigation groundwater source

Livestock Watering = protection of a potential livestock watering groundwater resource

Wildlife Watering = protection of groundwater discharging to a surface water body from which wildlife may drink

Table 3-3. Groundwater Remediation Guideline Values for Residential/Parkland - All Water Uses

This table must <u>not</u> be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Table 2. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Water Use	Lowest Guideline		Potable	Inhalation		Eco Soil Contact		Aquatic Life	
Soil Type	Fine	Coarse	All	Fine	Coarse	Fine	Coarse	Fine	Coarse
Unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
General and Inorganic Parameters									
pH	6.5-8.5	6.5-8.5	6.5-8.5	-	-	-	-	6.5-9	6.5-9
Ammonia	see note d	see note d	-	-	-	-	-	see note d	see note d
Chloride	230	230	250	-	-	-	-	230	230
Cyanide	0.005	0.005	0.2	-	-	-	-	0.005	0.005
Fluoride	0.12	0.12	1.5	-	-	-	-	0.12	0.12
Nitrate	13	13	45	-	-	-	-	13	13
Nitrite (as nitrogen)	0.06	0.06	1.0	-	-	-	-	0.06	0.06
Sodium	200	200	200	-	-	-	-	-	-
Sulphate	500	500	500	-	-	-	-	-	-
Sulphide (as H_2S)	0.002	0.002	0.05	-	-	-	-	0.002	0.002
Total Dissolved Solids (TDS)	500	500	500	-	-	-	-	-	-
Metals									
Aluminum	see note d	see note d	-	-	-	-	-	see note d	see note d
Antimony	0.006	0.006	0.006	-	-	-	-	-	-
Arsenic	0.005	0.005	0.01	-	-	-	-	0.005	0.005
Barium	1	1	1	-	-	-	-	-	-
Boron	5	5	5	-	-	-	-	-	-
Bromate	0.01	0.01	0.01	-	-	-	-	-	-
Cadmium	See note e	See note e	0.005	-	-	-	-	see note d	see note d
Chromium (Total)	See note e	See note e	0.05	-	-	-	-	see note d	see note d
Copper	See note e	See note e	1	-	-	-	-	see note d	see note d
Iron	0.3	0.3	0.3	-	-	-	-	0.3	0.3
Lead	See note e	See note e	0.01	-	-	-	-	see note d	see note d
Manganese	0.05	0.05	0.05	-	-	-	-	-	-

Table B-3. Groundwater Remediation Guideline Values for Residential/Parkland - All Water Uses

This table must <u>not</u> be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Table 2. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Water Use	Lowest Guideline		Potable	Inhalation		Eco Soil Contact		Aquatic Life	
Soil Type	Fine	Coarse	All	Fine	Coarse	Fine	Coarse	Fine	Coarse
Unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Mercury	See note e	See note e	0.001	-	-	-	-	see note d	see note d
Nickel	see note d	see note d	-	-	-	-	-	see note d	see note d
Selenium	0.001	0.001	0.01	-	-	-	-	0.001	0.001
Silver	see note d	see note d	-	-	-	-	-	see note d	see note d
Uranium	0.02	0.02	0.02	-	-	-	-	-	-
Zinc	0.03	0.03	5	-	-	-	-	0.03	0.03
Hydrocarbons									
Benzene	0.005	0.005	0.005	2.8	0.14	100	61	33	0.69
Toluene	0.024	0.024	0.024	NGR	74	82	59	NGR	0.083
Ethylbenzene	0.0024	0.0024	0.0024	NGR	16	42	20	NGR	41
Xylenes	0.3	0.3	0.3	80	3.9	21	31	NGR	18
Styrene	0.072	0.072	2.8	90	4.3	-	-	0.072	0.072
F1	2.2	0.81	2.2	19	0.81	6.5	7.1	NGR	9.8
F2	1.1	1.1	1.1	NGR	1.5	1.8	1.8	NGR	1.3
Acenapthene	0.0058	0.0058	1.4	NGR	NGR	-	-	0.0058	0.0058
Acenaphthylene	0.046	0.046	-	-	-	-	-	0.046	0.046
Anthracene	0.000012	0.000012	NGR	NGR	NGR	0.025	0.025	0.000012	0.000012
Fluoranthene	0.00004	0.00004	NGR	NGR	NGR	0.24	0.24	0.00004	0.00004
Fluorene	0.003	0.003	0.94	NGR	NGR	-	-	0.003	0.003
Naphthalene	0.0011	0.0011	0.47	14	0.6	-	-	0.0011	0.0011
Phenanthrene	0.0004	0.0004	-	-	-	-	-	0.0004	0.0004
Pyrene	0.000025	0.000025	0.71	NGR	NGR	-	-	0.000025	0.000025
Carcinogenic PAHs (as B(a)P TPE) [a]	0.00001	0.00001	0.00001	-	-	-	-	-	-
Benz[a]anthracene [b]	0.000018	0.000018	-	-	-	-	-	0.000018	0.000018
Benzo[b+j]fluoranthene [b]	0.00048	0.00048	-	-	-	-	-	0.00048	0.00048

Table B-3. Groundwater Remediation Guideline Values for Residential/Parkland - All Water Uses

This table must <u>not</u> be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Table 2. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Water Use	Lowest Guideline		Potable	Inhalation		Eco Soil Contact		Aquatic Life	
Soil Type	Fine	Coarse	All	Fine	Coarse	Fine	Coarse	Fine	Coarse
Unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Benzo[k]fluoranthene [b]	0.00048	0.00048	-	-	-	-	-	0.00048	0.00048
Benzo[g,h,i]perylene [b]	0.00021	0.00017	-	-	-	-	-	0.00021	0.00017
Benzo[a]pyrene [b]	0.000017	0.000015	-	-	-	0.0018	0.0018	0.000017	0.000015
Chrysene [b]	0.0014	0.0014	-	-	-	-	-	0.0014	0.0014
Dibenz[a,h]anthracene [b]	0.00028	0.00026	-	-	-	-	-	0.00028	0.00026
Indeno[1,2,3-c,d]pyrene [b]	0.00023	0.00021	-	-	-	-	-	0.00023	0.00021
Halogenated Aliphatics									
Vinyl chloride	0.002	0.0011	0.002	0.018	0.0011	-	-	-	-
1,1-Dichloroethene	0.014	0.014	0.014	0.68	0.039	-	-	-	-
Trichloroethene (Trichloroethylene, TCE)	0.005	0.005	0.005	0.41	0.02	4.4	5	0.27	0.029
Tetrachloroethene (Tetrachloroethylene, Perchloroethylene, PCE)	0.03	0.03	0.03	2.3	0.11	-	-	0.11	0.11
1,2-Dichloroethane	0.005	0.005	0.005	0.17	0.01	-	-	0.1	0.1
Dichloromethane (Methylene chloride)	0.05	0.05	0.05	61	3.4	-	-	0.098	0.098
Trichloromethane (Chloroform)	0.0018	0.0018	0.093	0.05	0.003	-	-	0.0018	0.0018
Tetrachloromethane (Carbon tetrachloride)	0.005	0.00056	0.005	0.011	0.00056	-	-	0.013	0.013
Dibromochloromethane	0.19	0.19	0.19	26	1.1	-	-	-	-
Chlorinated Aromatics									
Chlorobenzene	0.0013	0.0013	0.03	0.3	0.014	-	-	0.0013	0.0013
1,2-Dichlorobenzene	0.0007	0.0007	0.003	116	5.4	-	-	0.0007	0.0007
1,4-Dichlorobenzene	0.001	0.001	0.001	4.6	0.22	-	-	0.026	0.026
1,2,3-Trichlorobenzene	0.008	0.008	0.014	0.8	0.032	-	-	0.008	0.008
1,2,4-Trichlorobenzene	0.015	0.015	0.015	0.71	0.028	-	-	0.024	0.024
1,3,5-Trichlorobenzene	0.014	0.014	0.014	0.38	0.015	-	-	-	-
1,2,3,4-Tetrachlorobenzene	0.0018	0.0018	0.032	NGR	0.14	-	-	0.0018	0.0018

Table B-3. Groundwater Remediation Guideline Values for Residential/Parkland - All Water Uses

This table must <u>not</u> be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Table 2. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Water Use	Lowest Guideline		Potable	Inhalation		Eco Soil Contact		Aquatic Life	
Soil Type	Fine	Coarse	All	Fine	Coarse	Fine	Coarse	Fine	Coarse
Unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
1,2,3,5-Tetrachlorobenzene	0.0038	**0.0038**	0.0038	0.41	0.017	-	-	-	-
1,2,4,5-Tetrachlorobenzene	0.002	**0.002**	0.002	0.21	0.0088	-	-	-	-
Pentachlorobenzene	0.006	**0.006**	0.0094	NGR	0.038	-	-	0.006	0.006
Hexachlorobenzene	0.00057	**0.00057**	0.00057	0.029	0.0012	-	-	-	-
2,4-Dichlorophenol	0.0002	**0.0002**	0.0003	NGR	1500	-	-	0.0002	0.0002
2,4,6-Trichlorophenol	0.002	**0.002**	0.002	NGR	54	-	-	0.018	0.018
2,3,4,6-Tetrachlorophenol	0.001	**0.001**	0.001	NGR	NGR	-	-	0.001	0.001
Pentachlorophenol	0.0005	**0.0005**	0.03	NGR	NGR	0.87	0.88	0.0005	0.0005
Dioxins & Furans[c]	0.00000012	**0.00000012**	0.00000012	-	-	-	-	-	-
PCBs	0.0094	**0.0094**	0.0094	-	-	-	-	-	-
Pesticides									
Aldicarb	0.001	**0.001**	0.009	-	-	-	-	0.001	0.001
Aldrin	0.0007	**0.0007**	0.0007	-	-	-	-	0.003	0.003
Atrazine and metabolites	0.0018	**0.0018**	0.005	-	-	-	-	0.0018	0.0018
Azniphos-methyl	0.00001	**0.00001**	0.02	-	-	-	-	0.00001	0.00001
Bendiocarb	0.04	**0.04**	0.04	-	-	-	-	-	-
Bromoxynil	0.005	**0.005**	0.005	-	-	-	-	0.005	0.005
Carbaryl	0.0002	**0.0002**	0.09	-	-	-	-	0.0002	0.0002
Carbofuran	0.0018	**0.0018**	0.09	-	-	-	-	0.0018	0.0018
Chlorothalonil	0.00018	**0.00018**	0.14	-	-	-	-	0.00018	0.00018
Chlorpyrifos	0.0000035	**0.0000035**	0.09	-	-	-	-	0.0000035	0.0000035
Cyanazine	0.002	**0.002**	0.01	-	-	-	-	0.002	0.002
2,4-D	0.004	**0.004**	0.1	-	-	-	-	0.004	0.004
DDT	0.000001	**0.000001**	0.093	-	-	-	-	0.000001	0.000001
Diazinon	0.02	**0.02**	0.02	-	-	-	-	-	-

Table B-3. Groundwater Remediation Guideline Values for Residential/Parkland - All Water Uses

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Table 2. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Water Use	Lowest Guideline		Potable	Inhalation		Eco Soil Contact		Aquatic Life	
Soil Type	Fine	Coarse	All	Fine	Coarse	Fine	Coarse	Fine	Coarse
Unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Dicamba	0.01	0.01	0.12	-	-	-	-	0.01	0.01
Dichlofop-methyl	0.0061	0.0061	0.009	-	-	-	-	0.0061	0.0061
Dieldrin	0.000056	0.000056	0.0007	-	-	-	-	0.000056	0.000056
Dimethoate	0.0062	0.0062	0.02	-	-	-	-	0.0062	0.0062
Dinoseb	0.00005	0.00005	0.01	-	-	-	-	0.00005	0.00005
Diquat	0.07	0.07	0.07	-	-	-	-	-	-
Diuron	0.15	0.15	0.15	-	-	-	-	-	-
Endosulfan	0.00002	0.00002	0.057	-	-	-	-	0.00002	0.00002
Endrin	0.000036	0.000036	0.0028	-	-	-	-	0.000036	0.000036
Glyphosate	0.065	0.065	0.28	-	-	-	-	0.065	0.065
Heptachlor epoxide	0.0000038	0.0000038	0.000052	0.0043	0.00024	-	-	0.0000038	0.0000038
Lindane	0.00001	0.00001	0.0028	-	-	-	-	0.00001	0.00001
Linuron	0.007	0.007	0.019	-	-	-	-	0.007	0.007
Malathion	0.0001	0.0001	0.19	-	-	-	-	0.0001	0.0001
MCPA	0.0026	0.0026	0.0047	-	-	-	-	0.0026	0.0026
Methoxychlor	0.00003	0.00003	0.9	-	-	-	-	0.00003	0.00003
Metolachlor	0.0078	0.0078	0.05	-	-	-	-	0.0078	0.0078
Metribuzin	0.001	0.001	0.08	-	-	-	-	0.001	0.001
Paraquat (as dichloride)	0.01	0.01	0.01	-	-	-	-	-	-
Parathion	0.000013	0.000013	0.05	-	-	-	-	0.000013	0.000013
Phorate	0.002	0.002	0.002	-	-	-	-	-	-
Picloram	0.029	0.029	0.19	-	-	-	-	0.029	0.029
Simazine	0.01	0.01	0.01	-	-	-	-	0.01	0.01
Tebuthiuron	0.0016	0.0016	0.66	-	-	-	-	0.0016	0.0016
Terbufos	0.001	0.001	0.001	-	-	-	-	-	-

Table B-3. Groundwater Remediation Guideline Values for Residential/Parkland - All Water Uses

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Table 2. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Water Use	Lowest Guideline		Potable	Inhalation		Eco Soil Contact		Aquatic Life	
Soil Type	Fine	Coarse	All	Fine	Coarse	Fine	Coarse	Fine	Coarse
Unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Toxaphene	0.0000002	0.0000002	0.00043	6.4	0.31	-	-	0.0000002	0.0000002
Triallate	0.00024	0.00024	0.12	-	-	-	-	0.00024	0.00024
Trifluarin	0.0002	0.0002	0.045	-	-	-	-	0.0002	0.0002
Other Organics									
Aniline	0.0022	0.0022	0.066	1,900	87	-	-	0.0022	0.0022
Bis(2-ethyl-hexyl)phthalate	0.016	0.016	0.41	NGR	NGR	-	-	0.016	0.016
Dibutyl phthalate	0.019	0.019	0.59	NGR	NGR	-	-	0.019	0.019
Dichlorobenzidine	0.007	0.007	0.007	NGR	NGR	-	-	-	-
Diisopropanolamine	1.6	1.6	3.6	-	-	160	160	1.6	1.6
Ethylene glycol	31	31	31	NGR	NGR	9,200	16,000	190	190
Hexachlorobutadiene	0.0013	0.0013	0.006	0.031	0.0013	-	-	0.0013	0.0013
Methylmethacrylate	0.47	0.47	0.47	17	0.84	-	-	-	-
MTBE	0.015	0.015	0.015	6.1	0.34	-	-	10	10
Nitrilotriacetic acid	0.4	0.4	0.4	-	-	-	-	-	-
Nonylphenol + ethoxylates	0.001	0.001	-	-	-	0.0081	0.0081	0.001	0.001
Phenol	0.004	0.004	0.57	73,000	3,700	110	150	0.004	0.004
Sulfolane	0.09	0.09	0.09	-	-	1,700	2,800	50	50
Trihalomethanes - total (THMs)	0.1	0.1	0.1	-	-	-	-	-	-

Table B-3. Groundwater Remediation Guideline Values for Residential/Parkland - All Water Uses

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Table 2. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Notes:

a. B[a]P TPE (Total Potency Equivalents) are calculated by multiplying the groundwater concentration of individual carcinogenic PAHs by a standardized Benzo[a]pyrene Potency Equivalence to produce a Benzo[a]pyrene relative potency concentration, and by subsequently summing the relative potency concentrations for the entire PAH mixture. B[a]P PEFs are order of magnitude estimates of carcinogenic potential and are based on the World Health Organization (1999) scheme, as follows:

Carcinogenic PAH Compound	PEF
Benz[a]anthracene	0.1
Benzo(b+j)fluoranthene	0.1
Benzo[k]fluoranthene	0.1
Benzo[ghi]perylene	0.01
Benzo[a]pyrene	1
Chrysene	0.01
Dibenz[a,h]anthracene	1
Indeno[1,2,3-c,d]pyrene	0.1

b. For ecological receptors only.

c. Expressed as toxic equivalents (TEQs) based on 2,3,7,8-PCDD (See CCME, 1999 and updates)

d. See Surface Water Quality Guidelines for Use in Alberta (AENV, 1999) for further guidance on aquatic life pathway.

e. Tier 1 guideline = lowest of aquatic life guideline and potable GW guideline.

NGR - no guideline required, calculated value > solubility or >1,000,000 mg/L

Potable GW = protection of groundwater for potable drinking water

Inhalation = protection of volatilization from groundwater and migration into indoor air

Eco Soil Contact = protection of terrestrial plants and soil invertebrates in areas with shallow groundwater

Aquatic Life = protection of groundwater discharging to a surface water body hosting aquatic life

Table B-4. Groundwater Remediation Guideline Values for Commercial/Industrial - All Water Uses

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Table 2. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Pathway	Lowest Guideline		Potable	Inhalation		Eco Soil Contact		Aquatic Life	
Soil Type	Fine	Coarse	All	Fine	Coarse	Fine	Coarse	Fine	Coarse
Unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
General and Inorganic Parameters									
pH	6.5-8.5	6.5-8.5	6.5-8.5	-	-	-	-	6.5-9	6.5-9
Ammonia	see note d	see note d	-	-	-	-	-	see note d	see note d
Chloride	230	230	250	-	-	-	-	230	230
Cyanide	0.005	0.005	0.2	-	-	-	-	0.005	0.005
Fluoride	0.12	0.12	1.5	-	-	-	-	0.12	0.12
Nitrate	13	13	45	-	-	-	-	13	13
Nitrite (as nitrogen)	0.06	0.06	1.0	-	-	-	-	0.06	0.06
Sodium	200	200	200	-	-	-	-	-	-
Sulphate	500	500	500	-	-	-	-	-	-
Sulphide (as H_2S)	0.002	0.002	0.05	-	-	-	-	0.002	0.002
Total Dissolved Solids (TDS)	500	500	500	-	-	-	-	-	-
Metals									
Aluminum	see note d	see note d	-	-	-	-	-	see note d	see note d
Antimony	0.006	0.006	0.006	-	-	-	-	-	-
Arsenic	0.005	0.005	0.01	-	-	-	-	0.005	0.005
Barium	1	1	1	-	-	-	-	-	-
Boron	5	5	5	-	-	-	-	-	-
Bromate	0.01	0.01	0.01	-	-	-	-	-	-
Cadmium	See note e	See note e	0.005	-	-	-	-	see note d	see note d
Chromium (Total)	See note e	See note	0.05	-	-	-	-	see note d	see note d
Copper	See note e	See note e	1	-	-	-	-	see note d	see note d
Iron	0.3	0.3	0.3	-	-	-	-	0.3	0.3
Lead	See note e	See note e	0.01	-	-	-	-	see note d	see note d
Manganese	0.05	0.05	0.05	-	-	-	-	-	-
Mercury	See note e	See note e	0.001	-	-	-	-	see note d	see note d
Nickel	see note d	see note d	-	-	-	-	-	see note d	see note d
Selenium	0.001	0.001	0.01	-	-	-	-	0.001	0.001

Table B-4. Groundwater Remediation Guideline Values for Commercial/Industrial - All Water Uses

This table must <u>not</u> be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Table 2. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Pathway	Lowest Guideline		Potable	Inhalation		Eco Soil Contact		Aquatic Life	
Soil Type	Fine	Coarse	All	Fine	Coarse	Fine	Coarse	Fine	Coarse
Unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Silver	see note d	see note d	-	-	-	-	-	see note d	see note d
Uranium	0.02	0.02	0.02	-	-	-	-	-	-
Zinc	0.03	0.03	5	-	-	-	-	0.03	0.03
Hydrocarbons									
Benzene	0.005	0.005	0.005	19	1.8	540	350	33	0.69
Toluene	0.024	0.024	0.024	NGR	NGR	240	200	NGR	0.083
Ethylbenzene	0.0024	0.0024	0.0024	NGR	NGR	150	110	NGR	41
Xylenes	0.3	0.3	0.3	NGR	48	74	120	NGR	18
Styrene	0.072	0.072	2.8	NGR	51	-	-	0.072	0.072
F1	2.2	2.2	2.2	NGR	9.1	9.9	11	NGR	9.8
F2	1.1	1.1	1.1	NGR	17	3.1	3.1	NGR	1.3
Acenapthene	0.0058	0.0058	1.4	NGR	NGR	-	-	0.0058	0.0058
Acenaphthylene	0.046	0.046	-	-	-	-	-	0.046	0.046
Anthracene	0.000012	0.000012	NGR	NGR	NGR	0.32	0.32	0.000012	0.000012
Fluoranthene	0.00004	0.00004	NGR	NGR	NGR	0.86	0.86	0.00004	0.00004
Fluorene	0.003	0.003	0.94	NGR	NGR	-	-	0.003	0.003
Naphthalene	0.0011	0.0011	0.47	NGR	7	-	-	0.0011	0.0011
Phenanthrene	0.0004	0.0004	-	-	-	-	-	0.0004	0.0004
Pyrene	0.000025	0.000025	0.71	NGR	NGR	-	-	0.000025	0.000025
Carcinogenic PAHs (as B(a)P TPE) [a]	0.00001	0.00001	0.00001	-	-	-	-	-	-
Benz[a]anthracene [b]	0.000018	0.000018	-	-	-	-	-	0.000018	0.000018
Benzo[b+j]fluoranthene [b]	0.00048	0.00048	-	-	-	-	-	0.00048	0.00048
Benzo[k]fluoranthene [b]	0.00048	0.00048	-	-	-	-	-	0.00048	0.00048
Benzo[g,h,i]perylene [b]	0.00021	0.00017	-	-	-	-	-	0.00021	0.00017
Benzo[a]pyrene [b]	0.000017	0.000015	-	-	-	0.0066	0.0066	0.000017	0.000015
Chrysene [b]	0.0014	0.0014	-	-	-	-	-	0.0014	0.0014
Dibenz[a,h]anthracene [b]	0.00028	0.00026	-	-	-	-	-	0.00028	0.00026
Indeno[1,2,3-c,d]pyrene [b]	0.00023	0.00021	-	-	-	-	-	0.00023	0.00021

Table B-4. Groundwater Remediation Guideline Values for Commercial/Industrial - All Water Uses

This table must <u>not</u> be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Table 2. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Pathway	Lowest Guideline		Potable	Inhalation		Eco Soil Contact		Aquatic Life	
Soil Type	Fine	Coarse	All	Fine	Coarse	Fine	Coarse	Fine	Coarse
Unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Halogenated Aliphatics									
Vinyl chloride	0.002	**0.002**	0.002	0.12	0.013	-	-	-	-
1,1-Dichloroethene	0.014	**0.014**	0.014	4.5	0.49	-	-	-	-
Trichloroethene (Trichloroethylene, TCE)	0.005	**0.005**	0.005	2.8	0.25	73	83	0.27	0.029
Tetrachloroethene (Tetrachloroethylene, Perchloroethylene, PCE)	0.03	**0.03**	0.03	16	1.3	-	-	0.11	0.11
1,2-Dichloroethane	0.005	**0.005**	0.005	1.2	0.13	-	-	0.1	0.1
Dichloromethane (Methylene chloride)	0.05	**0.05**	0.05	410	43	-	-	0.098	0.098
Trichloromethane (Chloroform)	0.0018	**0.0018**	0.093	0.35	0.04	-	-	0.0018	0.0018
Tetrachloromethane (Carbon tetrachloride)	0.005	**0.005**	0.005	0.078	0.0068	-	-	0.013	0.013
Dibromochloromethane	0.19	**0.19**	0.19	250	10	-	-	-	-
Chlorinated Aromatics									
Chlorobenzene	0.0013	**0.0013**	0.03	2.2	0.18	-	-	0.0013	0.0013
1,2-Dichlorobenzene	0.0007	**0.0007**	0.003	NGR	64	-	-	0.0007	0.0007
1,4-Dichlorobenzene	0.001	**0.001**	0.001	32	2.6	-	-	0.026	0.026
1,2,3-Trichlorobenzene	0.008	**0.008**	0.014	6.9	0.33	-	-	0.008	0.008
1,2,4-Trichlorobenzene	0.015	**0.015**	0.015	6.1	0.29	-	-	0.024	0.024
1,3,5-Trichlorobenzene	0.014	**0.014**	0.014	3.3	0.15	-	-	-	-
1,2,3,4-Tetrachlorobenzene	0.0018	**0.0018**	0.032	NGR	NGR	-	-	0.0018	0.0018
1,2,3,5-Tetrachlorobenzene	0.0038	**0.0038**	0.0038	NGR	0.16	-	-	-	-
1,2,4,5-Tetrachlorobenzene	0.002	**0.002**	0.002	NGR	0.08	-	-	-	-
Pentachlorobenzene	0.006	**0.006**	0.0094	NGR	0.44	-	-	0.006	0.006
Hexachlorobenzene	0.00057	**0.00057**	0.00057	0.21	0.014	-	-	-	-
2,4-Dichlorophenol	0.0002	**0.0002**	0.0003	NGR	NGR	-	-	0.0002	0.0002
2,4,6-Trichlorophenol	0.002	**0.002**	0.002	NGR	540	-	-	0.018	0.018
2,3,4,6-Tetrachlorophenol	0.001	**0.001**	0.001	NGR	NGR	-	-	0.001	0.001
Pentachlorophenol	0.0005	**0.0005**	0.03	NGR	NGR	2.2	2.2	0.0005	0.0005
Dioxins & Furans[c]	0.00000012	**0.00000012**	0.00000012	-	-	-	-	-	-

Table B-4. Groundwater Remediation Guideline Values for Commercial/Industrial - All Water Uses

This table must <u>not</u> be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Table 2. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Pathway	Lowest Guideline		Potable	Inhalation		Eco Soil Contact		Aquatic Life	
Soil Type	Fine	Coarse	All	Fine	Coarse	Fine	Coarse	Fine	Coarse
Unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
PCBs	0.0094	0.0094	0.0094	-	-	-	-	-	-
Pesticides									
Aldicarb	0.001	0.001	0.009	-	-	-	-	0.001	0.001
Aldrin	0.0007	0.0007	0.0007	-	-	-	-	0.003	0.003
Atrazine and metabolites	0.0018	0.0018	0.005	-	-	-	-	0.0018	0.0018
Azniphos-methyl	0.00001	0.00001	0.02	-	-	-	-	0.00001	0.00001
Bendiocarb	0.04	0.04	0.04	-	-	-	-	-	-
Bromoxynil	0.005	0.005	0.005	-	-	-	-	0.005	0.005
Carbaryl	0.0002	0.0002	0.09	-	-	-	-	0.0002	0.0002
Carbofuran	0.0018	0.0018	0.09	-	-	-	-	0.0018	0.0018
Chlorothalonil	0.00018	0.00018	0.14	-	-	-	-	0.00018	0.00018
Chlorpyrifos	0.0000035	0.0000035	0.09	-	-	-	-	0.0000035	0.0000035
Cyanazine	0.002	0.002	0.01	-	-	-	-	0.002	0.002
2,4-D	0.004	0.004	0.1	-	-	-	-	0.004	0.004
DDT	0.000001	0.000001	0.093	-	-	-	-	0.000001	0.000001
Diazinon	0.02	0.02	0.02	-	-	-	-	-	-
Dicamba	0.01	0.01	0.12	-	-	-	-	0.01	0.01
Dichlofop-methyl	0.0061	0.0061	0.009	-	-	-	-	0.0061	0.0061
Dieldrin	0.000056	0.000056	0.0007	-	-	-	-	0.000056	0.000056
Dimethoate	0.0062	0.0062	0.02	-	-	-	-	0.0062	0.0062
Dinoseb	0.00005	0.00005	0.01	-	-	-	-	0.00005	0.00005
Diquat	0.07	0.07	0.07	-	-	-	-	-	-
Diuron	0.15	0.15	0.15	-	-	-	-	-	-
Endosulfan	0.00002	0.00002	0.057	-	-	-	-	0.00002	0.00002
Endrin	0.000036	0.000036	0.0028	-	-	-	-	0.000036	0.000036
Glyphosate	0.065	0.065	0.28	-	-	-	-	0.065	0.065
Heptachlor epoxide	0.0000038	0.0000038	0.000052	0.051	0.002	-	-	0.0000038	0.0000038
Lindane	0.00001	0.00001	0.0028	-	-	-	-	0.00001	0.00001

Table B-4. Groundwater Remediation Guideline Values for Commercial/Industrial - All Water Uses

This table must <u>not</u> be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Table 2. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Pathway	Lowest Guideline		Potable	Inhalation		Eco Soil Contact		Aquatic Life	
Soil Type	Fine	Coarse	All	Fine	Coarse	Fine	Coarse	Fine	Coarse
Unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Linuron	0.007	**0.007**	0.019	-	-	-	-	0.007	0.007
Malathion	0.0001	**0.0001**	0.19	-	-	-	-	0.0001	0.0001
MCPA	0.0026	**0.0026**	0.0047	-	-	-	-	0.0026	0.0026
Methoxychlor	0.00003	**0.00003**	0.9	-	-	-	-	0.00003	0.00003
Metolachlor	0.0078	**0.0078**	0.05	-	-	-	-	0.0078	0.0078
Metribuzin	0.001	**0.001**	0.08	-	-	-	-	0.001	0.001
Paraquat (as dichloride)	0.01	**0.01**	0.01	-	-	-	-	-	-
Parathion	0.000013	**0.000013**	0.05	-	-	-	-	0.000013	0.000013
Phorate	0.002	**0.002**	0.002	-	-	-	-	-	-
Picloram	0.029	**0.029**	0.19	-	-	-	-	0.029	0.029
Simazine	0.01	**0.01**	0.01	-	-	-	-	0.01	0.01
Tebuthiuron	0.0016	**0.0016**	0.66	-	-	-	-	0.0016	0.0016
Terbufos	0.001	**0.001**	0.001	-	-	-	-	-	-
Toxaphene	0.0000002	**0.0000002**	0.00043	75	2.9	-	-	0.0000002	0.0000002
Triallate	0.00024	**0.00024**	0.12	-	-	-	-	0.00024	0.00024
Trifluarin	0.0002	**0.0002**	0.045	-	-	-	-	0.0002	0.0002
Other Organics									
Aniline	0.0022	**0.0022**	0.066	13,000	1,000	-	-	0.0022	0.0022
Bis(2-ethyl-hexyl)phthalate	0.016	**0.016**	0.41	NGR	NGR	-	-	0.016	0.016
Dibutyl phthalate	0.019	**0.019**	0.59	NGR	NGR	-	-	0.019	0.019
Dichlorobenzidine	0.007	**0.007**	0.007	NGR	NGR	-	-	-	-
Diisopropanolamine	1.6	**1.6**	3.6	-	-	320	320	1.6	1.6
Ethylene glycol	31	**31**	31	NGR	NGR	15,000	26,000	190	190
Hexachlorobutadiene	0.0013	**0.0013**	0.006	0.22	0.015	-	-	0.0013	0.0013
Methylmethacrylate	0.47	**0.47**	0.47	120	10	-	-	-	-
MTBE	0.015	**0.015**	0.015	40	4.3	-	-	10	10
Nitrilotriacetic acid	0.4	**0.4**	0.4	-	-	-	-	-	-
Nonylphenol + ethoxylates	0.001	**0.001**	-	-	-	0.02	0.02	0.001	0.001

Table B-4. Groundwater Remediation Guideline Values for Commercial/Industrial - All Water Uses

This table must not be used for Tier 1 assessment and remediation, unless directed by Section 5.1.2. Tier 1 guidelines are found in Table 2. This table is provided to assist Tier 2 guideline development, using the procedures outlined in the companion Tier 2 document (AENV 2008a).

Pathway	Lowest Guideline		Potable	Inhalation		Eco Soil Contact		Aquatic Life	
Soil Type	Fine	Coarse	All	Fine	Coarse	Fine	Coarse	Fine	Coarse
Unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Phenol	0.004	0.004	0.57	NGR	45,000	730	1000	0.004	0.004
Sulfolane	0.09	0.09	0.09	-	-	3,400	5,700	50	50
Trihalomethanes - total (THMs)	0.1	0.1	0.1	-	-	-	-	-	-

Notes:

a B[a]P TPE (Total Potency Equivalents) are calculated by multiplying the groundwater concentration of individual carcinogenic PAHs by a standardized Benzo[a]pyrene Potency Equivalence to produce a Benzo[a]pyrene relative potency concentration, and by subsequently summing the relative potency concentrations for the entire PAH mixture. B[a]P PEFs are order of magnitude estimates of carcinogenic potential and are based on the World Health Organization (1999) scheme, as follows:

Carcinogenic PAH Compound	PEF
Benz[a]anthracene	0.1
Benzo(b+j)fluoranthene	0.1
Benzo[k]fluoranthene	0.1
Benzo[ghi]perylene	0.01
Benzo[a]pyrene	1
Chrysene	0.01
Dibenz[a,h]anthracene	1
Indeno[1,2,3-c,d]pyrene	0.1

b. For ecological receptors only.

c. Expressed as toxic equivalents (TEQs) based on 2,3,7,8-PCDD (See CCME, 1999 and updates)

d. See Surface Water Quality Guidelines for Use in Alberta (AENV, 1999) for further guidance on aquatic life pathway.

e. Tier 1 guideline = lowest of aquatic life guideline and potable GW guideline.

NGR - no guideline required, calculated value > solubility or >1,000,000 mg/L
Potable GW = protection of groundwater for potable drinking water
Inhalation = protection of volatilization from groundwater and migration into indoor air
Eco Soil Contact = protection of terrestrial plants and soil invertebrates in areas with shallow groundwater
Aquatic Life = protection of groundwater discharging to a surface water body hosting aquatic life

APPENDIX C - PROTOCOLS FOR CALCULATING ALBERTA TIER 1 SOIL AND GROUNDWATER REMEDIATION GUIDELINES

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1. INTRODUCTION

This Appendix provides the protocols, parameter values, and equations used to determine the numerical values for Alberta Tier 1 Soil and Groundwater Remediation Guidelines for each of the exposure pathways described in the main text.

1.1 Approach

A Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines (CCME, 2006a) was used as a starting point for developing the soil remediation guidelines. The protocol was adapted as appropriate.

Since the Canadian Council of Ministers of the Environment (CCME) issued their protocol for deriving soil quality guidelines (CCME, 2006a), the deliberations associated with the 2006 review of the Petroleum Hydrocarbon Canada-Wide Standard (PHC CWS; CCME, 2008a) have resulted in changes to a few additional parameters. Most of these parameter changes have been adopted here. Additionally, where appropriate, parameters have been adjusted to reflect the differences between conditions in Alberta and the assumptions in the CCME guidance that reflect conditions in the whole of Canada.

No CCME protocols are currently available for calculating groundwater guidelines. Accordingly, for each exposure pathway, the corresponding CCME protocol for the soil guideline was adapted to calculate a groundwater guideline. Where calculated groundwater values are greater than the solubility of the chemical in question, the guideline value is replaced in the appropriate table with "NGR" for "no guideline required".

2. PARAMETER VALUES

Parameter values used in the models that calculate the Alberta Tier 1 Soil and Groundwater Remediation Guidelines fall into two main groups: i) parameters relating to receptor exposure and properties of the site, referred to as "non-chemical-specific parameters"; and, ii) parameters that relate to the chemical properties, toxicity, or background exposure to chemicals, referred to as "chemical-specific parameters". These two groups of parameters are discussed below.

2.1 Non-Chemical-Specific Parameters

Parameter values used in the models in this section relating to human receptor characteristics, soil and hydrogeological parameters, site characteristics, building parameters, and livestock and wildlife receptor characteristics are summarized in Tables C-1 to C-5, respectively. All parameters are adopted directly from CCME (2006a) except where noted below.

In Table C-2, the saturated hydraulic conductivity for fine soils is 32 m/year for all exposure pathways, the lateral hydraulic gradient is 0.028, and the soil permeability to vapour flow is 10^{-9} cm^2 for fine soil and $6x10^{-8}$ cm^2 for coarse soil. These changes from parameter values in CCME (2006a) are based on the latest decisions made by the Soil Quality Guidelines Task Group of the CCME, and reflect the deliberations that took place during the process of revising the PHC CWS (CCME, 2008a). The groundwater recharge rate is 0.012 m/year in fine soil and 0.06 m/year in coarse soil. Groundwater recharge rates are based on extensive research by Atomic Energy of Canada Limited (AECL, 1990, 1991, 1992, and 1995) and hydrogeological literature for the prairies (*e.g.*, Trudell, 1994; Keller *et al.*, 1986; Woo and Rowsell, 1993). This work is consistent with groundwater recharge being less than 10% of precipitation in Coarse soils and less than 2% of precipitation in Fine soils. Taking these values together with precipitation data for the wettest of the Alberta locations for which climate normals are available (Edson: precipitation = 568 mm/year, based on 1961 to 1990 Canadian Climate Normals, Environment Canada, 2001) and rounding up, gives recharge values of 60 mm/year, and 12 mm/year for Coarse and Fine soils, respectively.

In Table C-4, the height for a residential building is 360 cm, and the air exchange rates for residential and commercial buildings are 0.5 and 0.9 exchanges/hour, respectively. Again, these changes from parameter values in CCME (2006a) are based on the latest decisions made by the Soil Quality Guidelines Task Group of the CCME, and reflect the deliberations that took place during the process of revising the PHC CWS (CCME, 2008a). In addition, for petroleum hydrocarbons only, there is an adjustment factor of 10 applied in the calculation of the indoor infiltration and inhalation guideline, reflecting empirical evidence that concentrations of petroleum hydrocarbon vapours in buildings are typically less than predicted values by this factor or more due to biodegradation in the subsurface and conservatism in the partitioning relationship as it applies to these substances. No adjustment factor is used for non-petroleum hydrocarbons, since no empirical evidence is available to support such a factor.

In Table C-5, the cattle body weight and water ingestion rate are the same as were used in CCME (2006a), and the soil ingestion rate is taken from NRC (1996). The meadow vole was selected as the surrogate ecological receptor that would be protective of the majority of wildlife species, based on its small home range and high soil and water ingestion rates relative to its bodyweight. Meadow vole body weight and water ingestion rate were taken from USEPA (1993). Meadow vole soil ingestion rate was calculated from data and equations provided in USEPA (1993) as follows:

$$SIR = FIR \cdot PSID$$

and

$$FIR = 0.0687 \cdot BW^{0.822} \cdot 1{,}000$$

Where:
- SIR = soil ingestion rate for meadow voles (g/day);
- PSID = proportion of soil in diet for meadow voles (0.024 – USEPA, 1993);
- FIR = food ingestion rate for meadow voles (2.41 g dry weight/day; calculated below);
- BW = meadow vole body weight (0.017 kg – minimum value from the range given in USEPA, 1993); and,
- 1,000 = conversion factor from kg to g.

Substituting these values in the above equation yields value for FIR of 2.41 g dry weight/day and for SIR of 0.058 g day (Table C-5).

2.2 Chemical-Specific Parameters

2.2.1 Physical Parameters

Physical parameters for the Alberta Tier 1 substances are summarized in Table C-6, together with an indication of the source for each. The parameters K_{oc} (organic carbon partition coefficient), H′ (dimensionless Henry's Law constant), and D_{air} (diffusion coefficient in air) are used in the soil and groundwater guideline models. Solubility was also included, to enable groundwater guideline values greater than solubility to be identified. References for each source are provided at the end of this appendix.

2.2.2 Toxicological Parameters

Human toxicity reference values (TRVs) for the Alberta Tier 1 substances are summarized in Table C-7, together with an indication of the source for each. For non-carcinogenic substances, the applicable TRVs are the tolerable daily intake (TDI) for oral exposure and the tolerable concentration (TC) for inhalation exposure. For carcinogens, the oral slope factor and the inhalation unit risk are provided in Table C-7. Where needed in the guideline calculations, the risk-specific dose and the risk-specific concentration were calculated as follows:

$$RsD = \frac{ARL}{SF}$$

$$RsC = \frac{ARL}{UR}$$

Where:

RsD	=	risk-specific dose (mg/kg bw per day);
ARL	=	acceptable risk level (10^{-5}, see below); and,
SF	=	slope factor (Table C-7); $(mg/kg\ bw\ per\ day)^{-1}$;
RsC	=	risk-specific concentration (mg/m^3);
UR	=	unit risk (Table C-7); $(mg/m^3)^{-1}$.

The acceptable risk level was set at 10^{-5} based on guidance in Health Canada (Health Canada, 2004a) and precedent from Alberta Environment.

TRVs were taken from the following sources, in order of preference:

- Health Canada;
- CCME guideline documents;
- The United States Environmental Protection Agency (IRIS database); and,
- The United States Oak Ridge National Laboratory toxicological database.

For volatile chemicals, if an inhalation tolerable concentration or unit risk was not available, one was estimated from the oral tolerable daily intake or the oral slope factor, using the adult body weight and inhalation rate provided in Table C-1. References for each source are provided at the end of this appendix.

2.2.3 Human Exposure Parameters

Human absorption factors are summarized in Table C-8.

Human background exposure parameters for the Alberta Tier 1 substances are summarized in Table C-9, together with an indication of the source for each. Note that background exposure rates are not required in the case of carcinogenic chemicals. Parameter values include toddler and adult estimated daily intake (EDI), which is the daily dose of chemical that an individual might receive from all non-site-related sources (assumed to be soil, water, air, food, and consumer products for Tier 1 guideline derivation), background air concentration (C_a), and soil allocation factor (SAF). The following sources of background exposure information were used, in order of preference:

- CCME guideline documents;
- Assessments carried out as part of the priority substance list (PSL) program under the Canadian Environmental Protection Act (CEPA); and,

- Information in the United States Agency for Toxic Substances and Disease Registry toxicological profiles.

Recognizing that a receptor might be exposed to contaminants from other sources than site-related soil, a soil allocation factor is used to ensure that exposure to contaminated soil represents only a portion of the overall allowable exposure. For the purposes of guideline calculation, exposure is assumed to be possible from five environmental compartments: soil, water, air, food, and consumer products (CCME, 2006a). Values for the soil allocation factor (SAF) were selected based on the following logic:

1. If a value of SAF other than the default value of 0.2 had previously been used in a guideline document, then that value was retained (e.g., hydrocarbon compounds, sulfolane, diisopropanolamine).
2. If the substance could exist in all five of the environmental compartments, then the default SAF of 0.2 was used.
3. If background exposure information was available and it was unlikely that the substance would appear in one of the five environmental compartments because of its chemical or physical properties, then an SAF of 0.25 was used to reflect exposure divided between the remaining four compartments.

References for each source are provided at the end of this appendix.

2.2.4 Petroleum Hydrocarbon Fractions

Petroleum hydrocarbons are a complex mixture of substances. To facilitate the calculation of risk-based soil and groundwater remediation guidelines, each fraction has been divided into several sub-fractions on the basis of chemical structure (aliphatic vs. aromatic) and carbon chain length.

Soil or groundwater remediation guidelines for each PHC fraction were developed by combining guidelines for each individual sub-fraction according to the proportion (by mass) of each sub-fraction within the fraction, according to the equation below:

$$SGRG\ (mg/kg-bw/day) = \frac{1}{\sum_i \frac{F_i}{SGRG_i}}$$

Where:

SGRG = soil (mg/kg) or groundwater (mg/L) remediation guideline;

F_i = the assumed proportion of the fraction in soil or groundwater made up of sub-fraction i (dimensionless, see below; values in Table C-10); and,

$SGRG_i$ = soil (mg/kg) or groundwater (mg/L) remediation guideline for sub-fraction "i" (mg/kg). For soil, maximum concentration set at $1x10^6$ mg/kg.

The assumed proportion of each sub-fraction differs for soil and groundwater, since each sub-fraction partitions differently between soil and groundwater. Assumed sub-fraction distributions for soil and groundwater are provided in Table C-10. The assumed sub-fraction distributions in soil are adopted directly from CCME (2008a). The assumed sub-fraction distributions in groundwater are calculated from the soil values by making standard equilibrium partitioning assumptions and using the following equations:

$$G_i = F_{i(soil)} \frac{\rho_b}{\theta_w + (K_{oc} \times f_{oc} \times \rho_b) + (H' \times \theta_a)}$$

and

$$F_{i(groundwater)} = \frac{G_i}{\sum_i G_i}$$

Where:

G_i	=	proportion of sub-fraction i in groundwater (before normalization; dimensionless);
$F_{i(soil)}$	=	proportion of sub-fraction i in soil (Table C-10; dimensionless);
$F_{i(groundwater)}$	=	proportion of sub-fraction i in groundwater (normalized; Table C-10; dimensionless);
ρ_b	=	dry soil bulk density (g/cm^3);
θ_w	=	moisture-filled porosity (dimensionless);
K_{oc}	=	organic carbon partition coefficient (L/kg);
f_{oc}	=	fraction of organic carbon (g/g);
H'	=	dimensionless Henry's Law Constant (dimensionless); and,
θ_a	=	vapour-filled porosity (dimensionless).

Guideline values for individual exposure pathways have been capped at a maximum value of 30,000 mg/kg to maintain consistency with the Canada-Wide Standard for Petroleum Hydrocarbons in Soil (CCME, 2008a).

2.2.5 Carcinogenic Polycyclic Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs) commonly occur as complex mixtures that may include compounds known or suspected to be carcinogenic. Soil and groundwater remediation guidelines have been calculated for benzo[a]pyrene. The benzo[a]pyrene guideline is applied to other carcinogenic PAHs through the use of Potency Equivalence Factors (PEFs). PEFs establish the toxicity of individual carcinogenic PAHs relative to benzo[a]pyrene. The notes in Appendix A and B explain the use of PEFs in more detail.

PEFs are also used in the calculation of soil guidelines for the protection of drinking water. The Risk Specific Dose (RSD) for benzo[a]pyrene is multiplied by the appropriate PEF to derive a RSD for each carcinogenic PAH. This value is then used in the calculation of individual soil guidelines for the protection of drinking water as explained in Section 5.1.2. These guidelines are then used with site-specific soil concentrations to calculate the Index of Additive Cancer Risk (IACR) as explained in the notes in Appendix A.

2.2.6 Water Quality Guidelines

Water quality guidelines for the Alberta Tier 1 chemicals are required as a starting point for calculating soil or groundwater remediation guidelines that are protective of groundwater uses. Values are summarized in Table C-11.

The values for human health were taken from the following sources, in order of preference:

- Health Canada Canadian Drinking Water Quality Guidelines (Health Canada, 2008);
- Drinking water guidelines that were calculated from the oral TRVs summarized in Table C-7 using the Health Canada approach (Health Canada, 1995). The adult exposure parameters used in the calculation are summarized in Table C-1. The proportion of total intake normally ingested in water was assumed to be equivalent to the soil allocation factor (Table C-9) because both are derived in the same manner and are typically equivalent.

The values for ecological receptors were taken from the following sources, in order of preference:

- Alberta Surface Water Quality Guidelines (AENV, 1999); and,
- Livestock or wildlife watering guidelines calculated from published daily threshold exposure doses (DTEDs) and the ecological exposure parameters presented in Table C-5.

3. HUMAN EXPOSURE PATHWAYS

3.1 Direct Contact

The model used to calculate the soil remediation guidelines protective of the human direct soil contact (soil ingestion, dermal contact, and particulate inhalation) is taken without change from CCME (2006a). Based on guidance in CCME (2006a), exposure via particulate inhalation was not considered for volatile compounds (IR_S was set to 0 kg/day for volatile chemicals in the equations below). Parameter values were discussed in Section 2, and parameter values are summarized in Tables C-1 to C-9. Separate calculations are made for carcinogens and non-carcinogenic chemicals.

Non-Carcinogens

$$SRG_{HH} = \frac{(TDI - EDI) \times SAF \times BW}{\left[(AF_G \times SIR) + (AF_L \times IR_S \times ET_2) + (AF_S \times SR)\right] \times ET_1} + [BSC]$$

Where:

SRG_{HH}	=	human health-based soil remediation guideline (mg/kg);
TDI	=	tolerable daily intake (mg/kg bw per day);
EDI	=	estimated daily intake (mg/kg bw per day);
SAF	=	soil allocation factor (dimensionless);
BW	=	adult or toddler body weight (kg);
AF_G	=	absorption factor for gut (dimensionless);
AF_L	=	absorption factor for lung (dimensionless);
AF_S	=	absorption factor for skin (dimensionless);
SIR	=	adult or toddler soil ingestion rate (kg/day);
IR_S	=	inhalation of particulate matter re-suspended from soil (kg/day);
SR	=	adult or toddler soil dermal contact rate (kg/day; calculated below);
ET_1	=	exposure term 1 (dimensionless) (days/week ÷ 7 x weeks/year ÷ 52);
ET_2	=	exposure term 2 (dimensionless) (hours/day ÷ 24); and,
BSC	=	background soil concentration (mg/kg).

Carcinogens

$$SRG_{HH} = \frac{(RsD) \times BW}{\left[(AF_G \times SIR) + (AF_L \times IR_S \times ET_2) + (AF_S \times SR)\right] \times ET_1} + [BSC]$$

Where:

SRG_{HH}	=	preliminary human health-based soil remediation guideline (mg/kg);
RsD	=	risk-specific dose (mg/kg bw per day);
BW	=	adult body weight (kg);
AF_G	=	absorption factor for gut (dimensionless);
AF_L	=	absorption factor for lung (dimensionless);
AF_S	=	absorption factor for skin (dimensionless);
SIR	=	adult soil ingestion rate (kg/day);
IR_S	=	inhalation of particulate matter re-suspended from soil (kg/day);
SR	=	adult soil dermal contact rate (kg/day);
ET_1	=	exposure term 1 (dimensionless) (days/week ÷ 7 x weeks/year ÷ 52);
ET_2	=	exposure term 2 (dimensionless) (hours/day ÷ 24); and,
BSC	=	background soil concentration (mg/kg).

Note that in contrast to the CCME (2006a) protocol, an exposure term based on the exposure scenario is used for commercial and industrial land use for carcinogens.

3.1.1 Soil Dermal Contact Rate

The soil dermal contact rate (SR) is the mass of contaminated soil which is assumed to contact the skin each day. This parameter is calculated as follows (CCME, 2006a):

$$SR = \{(SA_H \times DL_H) + (SA_O \times DL_O)\} \times EF$$

Where:

SR	=	soil dermal contact rate (kg/day);
SA_H	=	exposed surface area of hands (m^2);
DL_H	=	dermal loading of soil to hands (kg/m^2 per event);
SA_O	=	area of exposed body surfaces other than hands (m^2);
DL_O	=	dermal loading of soil to other surfaces (kg/m^2 per event); and,
EF	=	exposure frequency (events/day).

The soil dermal contact rate is calculated separately for toddlers and adults using the parameters in Table C-1.

3.2 Inhalation

Soil and groundwater guidelines protective of the indoor infiltration and inhalation pathway were calculated for volatile organic compounds using the equations from the CCME (2006a) protocol without change for soil and adapted as appropriate for groundwater.

3.2.1 Adjustment Factor

Consistent with the approach taken in CCME (2008a), an adjustment factor of 10 is applied in the equations below for petroleum hydrocarbons (see Section 2.1), to account for empirical evidence that measured indoor air concentrations are typically lower by at least this factor than concentrations predicted from the models below. The adjustment factor takes the value of 1 for all non-petroleum hydrocarbon chemicals, reflecting the lack of any empirical data to support such a factor for these chemicals.

3.2.2 Assumptions

Assumptions implicit in the model include the following:

- contaminant vapour immediately above the groundwater table is assumed to be in equilibrium with contaminant concentrations in the groundwater based on Henry's Law;
- the soil is physically and chemically homogeneous;
- cracks in the building floor slab are filled with dry material of the underlying soil type;
- the moisture content is uniform throughout the unsaturated zone;

- decay of the contaminant source is not considered (*i.e.*, infinite source mass);
- attenuation of the contaminant in the unsaturated zone is not considered, except in the case of hydrocarbons, where the adjustment factor accounts empirically for this and other processes;
- interactions of the contaminant with other chemicals or soil minerals are not considered.

3.2.3 Soil

Non-Carcinogens

$$SRG_I = \frac{(TC - C_a) \times [\theta_w + (K_{oc} \times f_{oc} \times \rho_b) + (H' \times \theta_a)] \times SAF \times DF_i \times 10^3 \times AF}{H' \times \rho_b \times ET \times 10^6} + BSC$$

Where:

SRG_I	=	soil remediation guideline for indoor infiltration (mg/kg);
TC	=	tolerable concentration (mg/m^3);
C_a	=	background air concentration (mg/m^3);
θ_w	=	moisture-filled porosity (dimensionless);
K_{oc}	=	organic carbon partition coefficient (L/kg);
f_{oc}	=	fraction of organic carbon (g/g);
ρ_b	=	dry soil bulk density (g/cm^3);
H′	=	Henry's Law Constant (dimensionless);
θ_a	=	vapour-filled porosity (dimensionless);
SAF	=	soil allocation factor (dimensionless);
DF_i	=	dilution factor from soil gas to indoor air (calculated below);
10^3	=	conversion factor from kg to g;
AF	=	adjustment factor (10, hydrocarbons; 1, non-petroleum hydrocarbons);
ET	=	exposure term (dimensionless);
10^6	=	conversion factor from m^3 to cm^3; and,
BSC	=	background soil concentration (mg/kg).

Carcinogens

$$SRG_I = \frac{RsC \times [\theta_w + (K_{oc} \times f_{oc} \times \rho_b) + (H' \times \theta_a)] \times DF_i \times 10^3 \times AF}{H' \times \rho_b \times ET \times 10^6} + BSC$$

Where:

SRG_I	=	soil remediation guideline for indoor infiltration (mg/kg);
RsC	=	risk-specific concentration (mg/m^3);
θ_w	=	moisture-filled porosity (dimensionless);
K_{oc}	=	organic carbon partition coefficient (L/kg);
f_{oc}	=	fraction of organic carbon (g/g);
ρ_b	=	dry soil bulk density (g/cm^3);
H′	=	Henry's Law Constant (dimensionless);
θ_a	=	vapour-filled porosity (dimensionless);
DF_i	=	dilution factor from soil gas to indoor air (calculated below);
10^3	=	conversion factor from kg to g;
AF	=	adjustment factor (10, hydrocarbons; 1, non-petroleum hydrocarbons);
ET	=	exposure term (dimensionless);
10^6	=	conversion factor from m^3 to cm^3; and,
BSC	=	background soil concentration (mg/kg).

Note that in contrast to the CCME (2006a) protocol, an exposure term of 0.2747 (corresponding to exposure to site-related contaminants for 10 hours/day, 5 days/week, and 48 weeks/year) is used for commercial and industrial land use for carcinogens.

3.2.4 Groundwater

Groundwater remediation guidelines were calculated using equations analogous to those above, but with adaptations to account for a groundwater, rather than soil, source.

Non-Carcinogens

$$GWRG_I = \frac{(TC - C_a) \times SAF \times DF_I \times AF}{H' \times ET \times 10^3}$$

Where:

$GWRG_I$	=	groundwater remediation guideline for indoor infiltration (mg/L);
TC	=	tolerable concentration (mg/m^3);
C_a	=	background air concentration (mg/m^3);
SAF	=	soil allocation factor (dimensionless);
DF_I	=	dilution factor from soil gas to indoor air (calculated below);
AF	=	adjustment factor (10, hydrocarbons; 1, non-petroleum hydrocarbons);
H′	=	Henry's Law Constant (dimensionless);
ET	=	exposure term (dimensionless); and,
10^3	=	conversion factor from m^3 to L.

Carcinogens

$$GWRG_I = \frac{RsC \times DF_I \times AF}{H' \times ET \times 10^3}$$

Where:

$GWRG_I$	=	groundwater remediation guideline for indoor infiltration (mg/L);
RsC	=	risk-specific concentration (mg/m^3);
DF_I	=	dilution factor from soil gas to indoor air (calculated below);
AF	=	adjustment factor (10, hydrocarbons; 1, non-petroleum hydrocarbons);
H′	=	Henry's Law Constant (dimensionless);
ET	=	exposure term (dimensionless);
10^3	=	conversion factor from m^3 to L; and,

Note that in contrast to the CCME (2006a) protocol, an exposure term of 0.2747 (corresponding to exposure to site-related contaminants for 10 hours/day, 5 days/week, and 48 weeks/year) is used for commercial and industrial land use for carcinogens.

3.2.5 Dilution Factor Calculation

This section presents the equations (CCME, 2006a) that were used to calculate the dilution factor in the above equations. The dilution factor (DF_I) was calculated as follows:

$$DF_i = \frac{1}{\alpha}$$

Where: DF_i = dilution factor from soil gas concentration to indoor air concentration (unitless); and,

α = attenuation coefficient (unitless; see derivation below).

Calculation of α

The attenuation coefficient, α, was calculated using the following equation:

$$\alpha = \frac{\left(\frac{D_T^{eff} A_B}{Q_B L_T}\right) exp\left(\frac{Q_{soil} L_{crack}}{D_{crack} A_{crack}}\right)}{exp\left(\frac{Q_{soil} L_{crack}}{D_{crack} A_{crack}}\right) + \left(\frac{D_T^{eff} A_B}{Q_B L_T}\right) + \left(\frac{D_T^{eff} A_B}{Q_{soil} L_T}\right)\left[exp\left(\frac{Q_{soil} L_{crack}}{D_{crack} A_{crack}}\right) - 1\right]}$$

Where:

α = attenuation coefficient (dimensionless);

D_T^{eff} = effective porous media diffusion coefficient (cm^2/s; calculated below);

A_B = building area (cm^2);

Q_B = building ventilation rate (cm^3/s; calculated below);

L_T = distance from contaminant source to foundation (cm);

Q_{soil} = volumetric flow rate of soil gas into the building (cm^3/s; calculated below);

L_{crack} = thickness of the foundation (cm);

D_{crack} = effective vapour diffusion coefficient through the crack (cm^2/s; calculated below); and,

A_{crack} = area of cracks through which contaminant vapours enter the building (cm^2).

Calculation of D_T^{eff}:

$$D_T^{eff} \approx D_a \times \left(\frac{\theta_a^{10/3}}{\theta_t^2}\right)$$

Where: D_T^{eff} = overall effective porous media diffusion coefficient based on vapour-phase concentrations for the region between the source and foundation (cm^2/s);

D_a = diffusion coefficient in air (cm^2/s);

θ_a = soil vapour-filled porosity (dimensionless); and,

θ_t = soil total porosity (dimensionless).

Calculation of D_{crack}:

D_{crack} is calculated in exactly the same way as D_T^{eff}, with the exception that the assumption is made that the soil material in the cracks is dry (CCME, 2006a), and accordingly, the air filled porosity is the same as the total porosity, and the equation becomes:

$$D_{crack} \approx D_a \times \left(\frac{\theta_t^{10/3}}{\theta_t^2} \right)$$

Where:
- D_{crack} = effective porous media diffusion coefficient in floor cracks (cm^2/s);
- D_a = diffusion coefficient in air (cm^2/s);
- θ_t = total porosity (dimensionless).

Calculation of Q_B:

$$Q_B = \frac{L_B W_B H_B ACH}{3{,}600}$$

Where:
- Q_B = building ventilation rate (cm^3/s);
- L_B = building length (cm);
- W_B = building width (cm);
- H_B = building height (cm);
- ACH = air exchanges per hour (h^{-1}); and,
- 3,600 = conversion factor from hours to seconds.

Calculation of Q_{soil}:

$$Q_{soil} = \frac{2\pi \Delta P k_v X_{crack}}{\mu \, ln\left[\frac{2Z_{crack}}{r_{crack}} \right]}$$

Where
- Q_{soil} = volumetric flow rate of soil gas into the building (cm^3/s);
- ΔP = pressure differential ($g/cm \cdot s^2$);
- k_v = soil vapour permeability to vapour flow (cm^2);
- X_{crack} = length of idealized cylinder (cm);
- μ = vapour viscosity (0.000173 g/cm·s; CCME, 2006a);
- Z_{crack} = distance below grade to idealized cylinder (cm); and,
- r_{crack} = radius of idealized cylinder (cm; calculated as A_{crack}/X_{crack}).

3.3 Offsite Migration

"Offsite Migration" guidelines are calculated to check that the guideline set for commercial and industrial land use will not result in adjacent more sensitive land being contaminated at levels above the applicable guideline for the sensitive land due to wind and/or water transport of contaminated soil from the commercial or industrial site. The guideline is calculated using the equation provided in the CCME (2006a) protocol:

$$SRG_{OM} = (14.3 \times SRG_A) - (13.3 \times BSC)$$

Where
- SRG_{OM}= soil remediation guideline protective of offsite migration (mg/kg);
- SRG_A = soil remediation guideline for human direct soil contact for agricultural land use (mg/kg); and,

BSC = background soil concentration (mg/kg).

A similar off-site migration check is calculated for ecological health using the ecological direct contact soil remediation guideline for agricultural land use.

4. ECOLOGICAL EXPOSURE PATHWAYS

4.1 Direct Contact

4.1.1 Soil

The exposure pathway considering direct contact of plants, soil invertebrates and microbes with contaminated soil is an important primary pathway in CCME (2006a), and is also important in the framework under which the Alberta Tier 1 guidelines were developed. Existing CCME soil quality guideline values were adopted for this exposure pathway. The reader is referred to CCME (2006a) for information on the protocol used to develop the existing guidelines for this exposure pathway.

The CCME recently reviewed the direct contact exposure pathway for petroleum hydrocarbon guidelines. As part of the review, a study was commissioned to review currently available data and identify suitable data for guideline derivation. The guideline derivation process followed CCME (2006a) recommendations as closely as possible. Some data came from research programmes that were not related to CCME guideline development, but that were nevertheless deemed to provide important information for guideline development. Alternative data treatments were developed for these data without compromising CCME or Alberta Environment protection goals. Details of the guideline derivation processes are documented in CCME (2008a). To maintain consistency with the CCME approach for benzene, toluene, ethylbenzene, and xylenes, subsoil ecocontact guidelines for petroleum hydrocarbons were set at twice the surface soil guidelines.

4.1.2 Groundwater

The direct contact of shallow groundwater with plants and soil invertebrates pathway is applicable whenever groundwater is present within 3 m of the ground surface. It applies to all land uses, and is based on the corresponding soil guideline. The approach for this exposure pathway for three different chemical classes is provided below.

Non-Polar Organic Compounds

Non-polar organic compounds can partition between soil organic carbon, pore water, and pore vapour, based on well-established partitioning equations. The guideline for this exposure pathway for these chemicals is calculated from existing eco soil contact soil remediation guidelines using standard assumptions for the partitioning of the contaminant between soil and pore water. Separate guidelines are calculated for coarse and fine soils, using the following equation:

$$GWRG_{DC} = SRG_{DC} \frac{\rho_b}{\theta_w + (K_{oc} \times f_{oc} \times \rho_b) + (H' \times \theta_g)}$$

Where: $GWRG_{DC}$= groundwater remediation guideline protective of direct contact with plants and soil invertebrates in areas of shallow groundwater (mg/L);

SRG_{DC} = soil remediation guideline protective of direct contact with plants and soil invertebrates (mg/kg);
ρ_b = dry soil bulk density (g/cm^3);
θ_w = moisture-filled porosity (dimensionless);
K_{oc} = organic carbon partition coefficient (L/kg);
f_{oc} = fraction of organic carbon (g/g);
H' = dimensionless Henry's Law Constant (dimensionless); and,
θ_a = vapour-filled porosity (dimensionless).

Soil remediation guidelines protective of ecological soil contact are available for selected chemicals in Appendix A.

Salt Compounds

Groundwater guidelines for salts are not calculated in this document.

Metals and Polar Organic Compounds

The potential interactions between metals or polar organic compounds and soils are complex in that they can be highly dependant on various environmental conditions including pH, clay mineralogy, redox conditions, and metal species present. Attempting to set groundwater guidelines for these chemicals for this pathway would involve significant uncertainty, and accordingly, it is recommended that concerns with potential adverse effects on surface soil biota from metals and polar organic compounds in shallow groundwater be addressed on a site-specific basis by analyzing soil samples.

4.2 Nutrient and Energy Cycling

Existing CCME soil quality guideline values were adopted for this exposure pathway. The reader is referred to CCME (2006a) for information on the protocol used to develop the existing guidelines for this exposure pathway.

4.3 Soil and Food Ingestion

The ingestion of contaminants in soil and contaminants bioaccumulated from soil into fodder by livestock or wildlife (soil and food ingestion pathway) forms part of the exposure scenario for natural areas or agricultural land use. Where available, existing CCME guideline values for metals for livestock soil and food ingestion were adopted without change. In general, these guidelines specifically considered livestock species, and so were not extrapolated to wildlife. Existing CCME guidelines for polycyclic aromatic hydrocarbons, polychlorinated biphenyls (PCBs), dioxins and furans, and DDT were also adopted without change for this exposure pathway. However, soil and food ingestion guidelines for these four compounds/groups considered primary, secondary and tertiary consumers, and accordingly the guidelines were considered protective of both livestock and wildlife.

Soil ingestion guidelines were calculated for benzene, toluene, ethylbenzene, and xylenes (BTEX) and petroleum hydrocarbon fractions F1 to F4. Petroleum hydrocarbons and BTEX are not considered to bioaccumulate into potential food species, and accordingly,

this guideline considered only soil ingestion for petroleum hydrocarbons. The following equation was used to calculate the soil ingestion guideline for PHCs. Livestock guidelines were calculated using parameters for a cow, as an economically important livestock species. Wildlife guidelines were calculated using parameters for a meadow vole. The meadow vole was selected since small animals are typically maximally exposed to contaminants. Wildlife soil ingestion guidelines calculated using the meadow vole are expected to be protective for the majority of wildlife species.

$$SRG_{SI\text{-}L\,W} = \frac{0.75 \times DTED \times BW_{L\,W}}{SIR_{L\,W} \times BF}$$

Where: $SRG_{SI\text{-}L\,W}$= soil remediation guideline for soil ingestion - livestock or wildlife (mg/kg);
0.75 = allocation factor (dimensionless);
DTED = daily threshold effect dose (mg/kg-bw/day);
$BW_{L\,W}$ = body weight - livestock or wildlife (kg);
$SIR_{L\,W}$ = soil ingestion rate - livestock or wildlife (kg/day); and,
BF = bioavailability factor (1.0; assumed).

4.4 Offsite Migration

"Offsite Migration" guidelines are calculated to check that the guideline set for commercial and industrial land use will not result in adjacent more sensitive land being contaminated at levels above the applicable guideline for the sensitive land due to wind and/or water transport of contaminated soil from the commercial or industrial site. The guideline is calculated using the equation provided in the CCME (2006a) protocol:

$$SRG_{OM} = (14.3 \times SRG_A) - (13.3 \times BSC)$$

Where SRG_{OM}= soil remediation guideline protective of offsite migration (mg/kg);
SRG_A = soil remediation guideline for ecological direct contact for agricultural land use (mg/kg); and,
BSC = background soil concentration (mg/kg).

A similar off-site migration check is calculated for human health using the human direct contact soil remediation guideline for agricultural land use.

5. GROUNDWATER PATHWAYS

This section provides the protocols used to calculate soil and groundwater remediation objectives protective of exposure pathways involving groundwater. The following receptors are considered:

- humans (potable drinking water sourced from groundwater);
- livestock (drinking water from a watering well, dugout, or surface water body potentially connected to contaminated groundwater);
- agricultural crops (irrigated from potentially contaminated groundwater);
- aquatic life (via lateral groundwater transport and discharge into a surface water body); and,
- wildlife (drinking water from a surface water body potentially connected to contaminated groundwater).

In the first three cases, it is assumed that the water well or dugout could potentially be installed at any location, and hence it is assumed that there is no lateral offset between the location where the contaminated soil or groundwater is measured and the receptor.

In the last two cases, a minimum lateral separation of 10 m is assumed between the location where the contaminated soil or groundwater is measured and the receptor (location of surface water body). In cases where contamination is present within 10 m of a surface water body, a Tier 2 or Exposure Control approach is required.

Surface water quality guidelines protective of the above water uses are provided in Table C-11, where available.

5.1 Soil Remediation Guidelines

Soil remediation guidelines for groundwater pathways were calculated using the model and equations from the CCME (2006a) protocol. Soil remediation guidelines for the protection of groundwater are not calculated for inorganic substances due to the uncertainties associated with the partitioning of metals between the adsorbed and dissolved phase as noted above; these substances should be assessed through site-specific groundwater sampling where these pathways are applicable.

5.1.1 Model Assumptions

Assumptions implicit in the model include the following:

1. the soil is physically and chemically homogeneous;
2. moisture content is uniform throughout the unsaturated zone;
3. infiltration rate is uniform throughout the unsaturated zone;
4. depletion of the contaminant source is not considered (*i.e.*, infinite source mass);
5. flow in the unsaturated zone is assumed to be one dimensional and downward only (vertical recharge) with dispersion, sorption-desorption, and biological degradation;

6. contaminant is not present as an immiscible phase product;
7. maximum possible concentration in the leachate is equivalent to the solubility limit of the chemical in water under the defined site conditions;
8. groundwater aquifer is unconfined;
9. groundwater flow is uniform and steady;
10. co-solubility and oxidation/reduction effects are not considered;
11. attenuation of the contaminant in the saturated zone is assumed to be one-dimensional with respect to sorption-desorption, dispersion, and biological degradation;
12. dispersion in groundwater is assumed to occur in the longitudinal and transverse directions only and diffusion is not considered;
13. mixing of the leachate with the groundwater is assumed to occur through mixing of leachate and groundwater mass fluxes; and
14. dilution of the plume by groundwater recharge down-gradient of the source is not included.

5.1.2 Guideline Calculation

The soil remediation guideline protective of groundwater uses is calculated in the same way for all five groundwater uses noted at the start of Section 5, using the corresponding surface water quality guideline as the starting point for each, with 2 exceptions. The first exception is that the lateral offset between the point at which the contaminated soil is measured and the surface water body (parameter "x" in the dilutilon factor 4 equation below) is assumed to be 10 m for aquatic life and wildlife watering, and zero for the other water uses. Therefore, dilution factor 4 is only active for aquatic life and wildlife watering and cannot be applied for other pathways. The second exception is that in the calculation of dilution factor 3 for the potable groundwater pathway only, the average thickness of the mixing zone (Z_d) takes the fixed value of 2 m, reflecting the likely minimum screen length for a viable drinking water well. It should be noted that this second point reflects Alberta Environment policy and is not consistent with CCME (2006a).

The model considers four processes:

1. partitioning of the substance from soil to pore water (leachate);
2. transport of the leachate from the base of contamination to the groundwater table;
3. mixing of the leachate with groundwater; and,
4. transport of the substance in groundwater down-gradient to a discharge point.

For each of these four processes, a dilution factor was calculated (DF1 through DF4, respectively). DF1 has units of (mg/kg)/(mg/L) or L/kg. The other three dilution factors are dimensionless [units of (mg/L)/(mg/L)]. The overall dilution factor is used to calculate the soil concentration that is protective of groundwater using the following equations:

$$SRG_{GR} = SWQG_{FL} \times DF$$

$$DF = DF1 \times DF2 \times DF3 \times DF4$$

Where:

SRG_{GR}	=	soil remediation guideline protective of groundwater pathways (mg/kg);
$SWQG_{FL}$	=	corresponding surface water quality guideline (drinking water, aquatic life, livestock or wildlife watering, or irrigation) (mg/L);
DF	=	overall dilution factor (L/kg);
DF1	=	dilution factor for process 1 (L/kg);
DF2	=	dilution factor for process 2 (dimensionless);
DF3	=	dilution factor for process 3 (dimensionless); and,
DF4	=	dilution factor for process 4 (dimensionless).

Dilution Factor 1

Dilution factor 1 (DF1) is the ratio of the concentration of a contaminant in soil to the concentration in leachate that is in contact with the soil. This "dilution factor" represents the three phase partitioning between contaminant sorbed to soil, contaminant dissolved in pore water (*i.e.*, as leachate), and contaminant present as soil vapour. DF1 is calculated using the following equation:

$$DF1 = K_{oc} \times f_{oc} + \frac{(\theta_w + H' \times \theta_a)}{\rho_b}$$

Where:

DF1	=	dilution factor 1 (L/kg);
K_{oc}	=	organic carbon-water partition coefficient (L/kg);
f_{oc}	=	fraction organic carbon (g/g);
θ_w	=	water filled porosity (dimensionless);
H′	=	dimensionless Henry's Law constant (dimensionless);
θ_a	=	air filled porosity (dimensionless); and,
ρ_b	=	dry soil bulk density (g/cm^3).

Dilution Factor 2

Dilution factor 2 (DF2) is the ratio of the concentration of a contaminant in leachate that is in contact with the soil, to the concentration in pore water just above the groundwater table. DF2 takes the value 1.00 (*i.e.*, no dilution) for generic guidelines because it is assumed at Tier 1 that the contaminated soil extends down to the water table.

Dilution Factor 3

Dilution factor 3 (DF3) is the ratio of the concentration of a chemical in pore water just above the groundwater table, to the concentration in groundwater beneath the source. This dilution factor reflects a decrease in concentration as leachate mixes with uncontaminated groundwater. DF3 is a function of groundwater velocity, infiltration rate, source length, and mixing zone thickness. The mixing zone thickness is calculated as being due to two processes: i) mixing due to dispersion, and ii) mixing due to infiltration rate. The equations used are as follows:

$$DF3 = 1 + \frac{Z_d \times V}{I \times X}$$

$$Z_d = r + s$$

$$r = 0.01 \times X$$

$$s = d_a \left\{ 1 - exp\left(\frac{-2.178 \times X \times I}{V \times d_a} \right) \right\}$$

$$V = K \times i$$

Where:

DF3	=	dilution factor 3 (dimensionless);
Z_d	=	average thickness of mixing zone (m);
V	=	Darcy velocity in groundwater (m/year);
I	=	infiltration rate (m/year);
X	=	length of contaminated soil parallel to groundwater flow (m);
r	=	mixing depth due to dispersion (m);
s	=	mixing depth due to infiltration rate (m);
d_a	=	unconfined aquifer thickness (m);
K	=	aquifer hydraulic conductivity (m/year); and,
i	=	lateral hydraulic gradient in aquifer (dimensionless).

Note that the parameter Z_d takes the fixed value of 2 m for the drinking water pathway, but is calculated as above for all other pathways.

Dilution Factor 4

Dilution factor 4 (DF4) accounts for the processes of dispersion and biodegradation as groundwater travels downgradient from beneath the source of contamination, and is the ratio of the concentration of a chemical in groundwater beneath the source, to the concentration in groundwater at a distance (10 m for Tier 1 for aquatic life and wildlife watering) downgradient of the source. For distances less than 10 m, a value of 1 should be used for DF4. Consistent with CCME (2006b), the time independent (steady state) version of the equation to calculate DF4 was used:

$$DF4 = \frac{2}{\exp(A) \times [erf(C) - erf(D)]}$$

$$A = \frac{x}{2D_x} \left\{ 1 - \left(1 + \frac{4L_x D_x}{v} \right)^{1/2} \right\}$$

$$C = \frac{y + Y/2}{2\left(D_y x\right)^{1/2}}$$

$$D = \frac{y - Y/2}{2\left(D_y x\right)^{1/2}}$$

$$L_s = \frac{0.6931}{t_{1/2s}} \times \exp\left(-0.07d\right)$$

$$v = \frac{V}{\theta_t R_s}$$

$$R_s = 1 + \frac{\rho_b K_{oc} f_{oc}}{\theta_t}$$

$$D_x = 0.1x$$

$$D_y = 0.01x$$

Where:

DF4	=	dilution factor 4 (dimensionless);
erf	=	the error function;
A	=	group A (dimensionless);
C	=	group C (dimensionless);
D	=	group D (dimensionless);
x	=	distance to source (10 m, aquatic life and wildlife watering, 0 m other water uses);
D_x	=	dispersivity in the direction of groundwater flow (m);
L_s	=	decay constant (1/year);
v	=	velocity of the contaminant (m/year);
y	=	distance to receptor perpendicular to groundwater flow (0 m);
Y	=	source width perpendicular to groundwater flow (m);
D_y	=	dispersivity perpendicular to the direction of groundwater flow (m);
$t_{1/2s}$	=	decay half-life of contaminant in saturated zone of aquifer (years);
d	=	water table depth (m);
V	=	Darcy velocity in groundwater (m/year);
θ_t	=	total soil porosity (dimensionless);
R_s	=	retardation factor in saturated zone (dimensionless);
ρ_b	=	dry soil bulk density (g/cm^3);
K_{oc}	=	organic carbon partition coefficient (mL/g); and,
f_{oc}	=	fraction organic carbon (g/g).

5.2 Groundwater Remediation Guidelines

It is assumed that a dugout could potentially be constructed at any location on agricultural land and, accordingly, the livestock watering and irrigation water quality guidelines are applicable as groundwater remediation guidelines across all agricultural land. (see Table C-10). Furthermore, it is assumed that a water well could be constructed anywhere within a Domestic Use Aquifer (DUA). Accordingly, drinking water quality guidelines must be applied as groundwater remediation guidelines within the entire DUA . Therefore any modification of these guidelines is considered Exposure Control.

For aquatic life or wildlife watering, it is assumed that there is a minimum 10 m lateral separation between the point of measurement and the surface water body.

5.2.1 Model Assumptions

Assumptions implicit in the model include the following:

- the soil/aquifer material in the saturated zone is physically and chemically homogeneous;
- decay of the contaminant source is not considered (*i.e.*, infinite source mass);
- the contaminant is not present as a free phase product;
- groundwater flow is uniform and steady;
- co-solubility and oxidation/reduction effects are not considered;
- dispersion is assumed to occur in the longitudinal and transverse directions only and diffusion is not considered; and,
- dilution of the plume by groundwater recharge down-gradient of the source is not included.

5.2.2 Guideline Calculation – Aquatic Life and Wildlife Watering

The groundwater remediation guideline protective of aquatic life and wildlife watering is calculated using the following equations.

$$GWRG_{GR} = SWQG_{FL} \times DF4$$

Where:

$GWRG_{GR}$= groundwater remediation guideline protective of groundwater pathways (mg/kg);

$SWQG_{FL}$= corresponding surface water quality guideline (aquatic life, or wildlife watering) (mg/L);

DF4 = dilution factor for process 4 (L/kg).

Dilution factor 4 is calculated in the same way as described in Section 5.1.2

For inorganic substances, the aquatic life surface water quality guidelines have been adopted directly because the processes that affect their transport in groundwater do not meet the model assumptions.

6. OTHER CONSIDERATIONS

In addition to the exposure pathways described above, there are a range of other considerations relating to soil and groundwater contamination management including:

- aesthetics/nuisance issues, including smell, taste, and colour.
- concerns with damage to buried infrastructure (concrete foundations, metal pilings or pipelines, fibre-optic communication cables, power cables, polymer piping and joints, etc.); and,
- safety concerns with the possible build-up of flammable vapours or the exposure of workers to dangerous atmospheres, particularly in confined spaces.

In this document, soil ecocontact guideline values that were derived under the CCME (2006a) protocol and previous versions implicitly incorporated the above soil management considerations in the ecological subsoil guidelines. However, separate soil management limits for petroleum hydrocarbons have been developed according to the *Canada-Wide Standards for Petroleum Hydrocarbons (PHCs) in Soil* (CCME 2008a). Specific considerations were given to free phase formation, exposure to workers in trenches, fire and explosive hazards, effects on buried infrastructure, aesthetic considerations, and other technological factors. Not all factors could be explored quantitatively so some decisions were based on a qualitative assessment of information for the given exposure pathway-receptor combination. Where ecocontact subsoil guidelines developed under the CCME protocol (CCME, 2006a or previous versions) remained reasonable for any other management considerations and where no other information could be obtained, values for the ecocontact subsoil guidelines were adopted as management limits.

Regardless of whether specific numerical values have been specified for the above considerations, the proponent is responsible for ensuring that these concerns are addressed by the site remediation and risk management activities.

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Table C-1. Human Receptor Characteristics

Parameter	Symbol	Unit	Toddler	Adult
Body Weight	BW	kg	16.5	70.7
Air Inhalation Rate	IR	m^3/d	9.3	15.8
Soil Inhalation Rate	IR_S	kg/d	7.1×10^{-9}	1.2×10^{-8}
Water Ingestion Rate	WIR	L/d	0.6	1.5
Soil Ingestion Rate	SIR	kg/d	0.00008	0.00002
Skin Surface Area				
- Hands	SA_H	m^2	0.043	0.089
- Other	SA_O	m^2	0.258	0.25
Dermal Loading to Skin				
- Hands	DL_H	kg/m^2-event	0.001	0.001
- Other	DL_O	kg/m^2-event	0.0001	0.0001
Dermal Exposure Frequency	EF	events/d	1	1
Exposure Term, agricultural and residential/parkland	ET	-	1	1
Exposure Term, commercial and industrial	ET	-	0.2747	0.2747
Exposure Term, agricultural and residential/parkland	ET_1	-	1	1
Exposure Term, commercial and industrial	ET_1	-	0.6593	0.6593
Exposure Term, agricultural and residential/parkland	ET_2	-	1	1
Exposure Term, commercial and industrial	ET_2	-	0.4167	0.4167

Notes:

All values from CCME (2006a)

Table C-2. Soil and Hydrogeological Parameters

Parameter	Symbol	Unit	Fine Soil	Coarse Soil	Notes
Soil Bulk Density	ρ_B	g/cm^3	1.4	1.7	
Soil Total Porosity	θ_t	cm^3/cm^3	0.47	0.36	
Soil Moisture-Filled Porosity	θ_w	cm^3/cm^3	0.168	0.119	
Soil Vapour-Filled Porosity	θ_a	cm^3/cm^3	0.302	0.241	
Fraction of Organic Carbon	f_{oc}	*mass/mass*	0.005	0.005	
Saturated Hydraulic Conductivity	K	*m/y*	32	320	
Hydraulic Gradient	i	*m/m*	0.028	0.028	
Recharge (Infiltration) Rate	I	*m/y*	0.012	0.06	1
Soil Permeability to Vapour Flow	k_v	cm^2	10^{-9}	$6x10^{-8}$	2

Notes:
All parameters values from CCME (2006a) except as noted
1. See Section 2.1
2. Fine grained value from CCME (2008a)

Table C-3. Site Characteristics

Parameter	Symbol	Unit	Value
Contaminant Source Width Perpendicular to Groundwater Flow	Y	m	10
Contaminant Source Length Parallel to Groundwater Flow	X	m	10
Contaminant Source Depth	Z	m	3
Distance to Surface Water	x	m	10
Distance to Potable Water User	x	m	0
Distance to Agricultural Water User	x	m	0
Distance from Contamination to Building Slab	L_T	cm	30
Depth to Groundwater (water table)	d	m	3
Depth of Unconfined Aquifer	d_a	m	5

Notes:
All values from CCME (2006a)

Table C-4. Building Parameters

Parameter	Symbol	Unit	Residential Basement		Residential Slab-on-Grade		Commercial Slab-on-Grade		Notes
			Other Hydrocarbons	Petroleum Hydrocarbons	Other Hydrocarbons	Petroleum Hydrocarbons	Other Hydrocarbons	Petroleum Hydrocarbons	
Adjustment Factor			1	10	1	10	1	10	1,2
Building Length	L_B	*cm*	1,225	1,225	1,225	1,225	2,000	2,000	
Building Width	W_B	*cm*	1,225	1,225	1,225	1,225	1,500	1,500	
Building Height (including basement)	H_B	*cm*	360	360	360	360	300	300	2
Area of Substructure	A_B	cm^2	$2.7x10^6$	$2.7x10^6$	$1.5x10^6$	$1.5x10^6$	$3.0x10^6$	$3.0x10^6$	
Thickness of Floor Slab	L_{crack}	*cm*	11.25	11.25	11.25	11.25	11.25	11.25	
Depth of Floor Slab Below Ground	Z_{crack}	*cm*	244	244	11.25	11.25	11.25	11.25	
Distance from Source to Slab:	L_T	*cm*							
surface soil			30	30	30	30	30	30	
subsoil			30	30	139	139	139	139	
Crack Area	A_{crack}	cm^2	994.5	994.5	994.5	994.5	1,846	1,846	
Crack Length	X_{crack}	*cm*	4,900	4,900	4,900	4,900	7,000	7,000	
Air Exchange Rate	ACH	*exch/hr*	0.5	0.5	0.5	0.5	0.9	0.9	2
Pressure Differential	ΔP	$g/cm{\cdot}s^2$	40	40	40	40	20	20	

Notes:
All parameters values from CCME (2006a) except as noted
1. *An application factor of 10 is applied to the calculation for hydrocarbons only to account for empirical evidence of reduction in predicted indoor air concentrations. No data are available to support such a correction for non-hydrocarbons, and accordingly no application factor is used for non-hydrocarbons.*
2. *From CCME (2008a)*

Table C-5. Livestock and Wildlife Receptor Characteristics

Parameter	Symbol	Unit	Livestock (Cow) [a]	Wildlife (Meadow Vole)
Body Weight	BW	kg	550 [a]	0.017 [c]
Soil Ingestion Rate	SIR	kg/d	0.747 [b]	0.000058 [d]
Water Ingestion Rate	WIR	L/d	100 [a]	0.00357 [a]

Notes:

a. CCME (2006a)

b. NRC (1996)

c. USEPA (1993)

d. calculated; see text

Table C-6. Chemical Parameters

	K_{oc} ml/g	Source	H' dimensionless	Source	D_a cm^2/s	Source	Solubility mg/L	Source	Half Life yr	Source
Hydrocarbons										
Benzene	81	EC (2004a)	0.225	EC (2004a)	8.80E-02	EC (2004a)	1780	Gustafson et al (1997)	1	BCMELP (1996)
Toluene	234	EC (2004b)	0.274	EC (2004b)	8.70E-02	EC (2004b)	515	Gustafson et al (1997)	0.288	BCMELP (1996)
Ethylbenzene	537	EC (2004b)	0.358	EC (2004b)	7.50E-02	EC (2004b)	152	Gustafson et al (1997)	0.312	BCMELP (1996)
Xylenes	586	EC (2004b)	0.252	EC (2004b)	7.80E-02	EC (2004b)	198	Gustafson et al (1997)	0.501	BCMELP (1996)
Styrene	461	Gustafson et al (1997)	0.123	Gustafson et al (1997)	7.10E-02	Gustafson et al (1997)	300	Gustafson et al (1997)		
F1									1.95	CCME (2008a)
F2									4.79	CCME (2008a)
Aliphatic C_6-C_8	3,981	CCME (2008a)	50	CCME (2008a)	5.00E-02	CCME (2008a)	5.4	CCME (2008a)		
Aliphatic C_8-C_{10}	31,623	CCME (2008a)	80	CCME (2008a)	5.00E-02	CCME (2008a)	0.43	CCME (2008a)		
Aliphatic C_{10}-C_{12}	251,189	CCME (2008a)	120	CCME (2008a)	5.00E-02	CCME (2008a)	0.034	CCME (2008a)		
Aliphatic C_{12}-C_{16}	5.01E+06	CCME (2008a)	520	CCME (2008a)	5.00E-02	CCME (2008a)	0.00076	CCME (2008a)		
Aliphatic C_{16}-C_{21}	6.31E+08	CCME (2008a)	4900	CCME (2008a)	5.00E-02	CCME (2008a)	0.0000025	CCME (2008a)		
Aliphatic C_{21}-C_{34}	1.0E+13	CCME (2008a)	5.6E+05	CCME (2008a)	5.00E-02	CCME (2008a)				
Aliphatic C_{34}	1.6E+08	CCME (2008a)	1.2E+08	CCME (2008a)	5.00E-02	CCME (2008a)				
Aromatic C_8-C_{10}	1,585	CCME (2008a)	0.48	CCME (2008a)	5.00E-02	CCME (2008a)	65	CCME (2008a)		
Aromatic C_{10}-C_{12}	2,512	CCME (2008a)	0.14	CCME (2008a)	5.00E-02	CCME (2008a)	25	CCME (2008a)		
Aromatic C_{12}-C_{16}	5,012	CCME (2008a)	0.053	CCME (2008a)	5.00E-02	CCME (2008a)	5.8	CCME (2008a)		
Aromatic C_{16}-C_{21}	15,849	CCME (2008a)	0.013	CCME (2008a)	5.00E-02	CCME (2008a)	0.65	CCME (2008a)		
Aromatic C_{21}-C_{34}	125,893	CCME (2008a)	0.00067	CCME (2008a)	5.00E-02	CCME (2008a)	0.0066	CCME (2008a)		
Aromatic C_{34}	1.8E+06	CCME (2008a)	0.000018	CCME (2008a)	5.00E-02	CCME (2008a)				
Acenapthene	2,818	CCME (2008b)	6.56E-03	CCME (2008b)	4.21E-02	USEPA (1996)	3.9	CCME (2008b)		
Acenaphthylene	5,623	CCME (2008b)	0.000478	CCME (2008b)			16.1	CCME (2008b)		
Anthracene	19,953	CCME (2008b)	0.0015	CCME (2008b)	3.24E-02	USEPA (1996)	0.057	CCME (2008b)		
Fluoranthene	41,687	CCME (2008b)	0.000609	CCME (2008b)	3.03E-02	USEPA (1996)	0.26	CCME (2008b)		
Fluorene	4,898	CCME (2008b)	0.00337	CCME (2008b)	3.63E-02	USEPA (1996)	1.9	CCME (2008b)		
Naphthalene	708	CCME (2008b)	0.020441	CCME (2008b)	5.90E-02	USEPA (1996)	31.7	CCME (2008b)		
Phenanthrene	6,607	CCME (2008b)	0.000986	CCME (2008b)	2.72E-02	USEPA (1996)	1.15	CCME (2008b)		
Pyrene	69,183	CCME (2008b)	0.000466	CCME (2008b)	2.72E-02	USEPA (1996)	1.35	CCME (2008b)		
Benz[a]anthracene	199,526	CCME (2008b)	0.000142	CCME (2008b)	5.01E-02	USEPA (1996)	0.0094	CCME (2008b)		
Benzo[b+j]fluoranthene	93,325	CCME (2008b)	0.000468	CCME (2008b)	2.26E-02	USEPA (1996)	0.00375	CCME (2008b)		
Benzo[k]fluoranthene	19,953	CCME (2008b)	0.0000351	CCME (2008b)	2.26E-02	USEPA (1996)	0.0008	CCME (2008b)		

Table C-6. Chemical Parameters

	K_{oc} ml/g	Source	H' dimensionless	Source	D_a cm^2/s	Source	Solubility mg/L	Source	Half Life yr	Source
Benzo[g,h,i]perylene	407,380	CCME (2008b)	0.00000597	CCME (2008b)			0.000026	CCME (2008b)		
Benzo[a]pyrene	2,187,762	CCME (2008b)	0.0000478	CCME (2008b)	4.30E-02	USEPA (1996)	0.0016	CCME (2008b)		
Chrysene	125,892	CCME (2008b)	0.004	CCME (2008b)	2.48E-02	USEPA (1996)	0.00415	CCME (2008b)		
Dibenz[a,h]anthracene	1,380,384	CCME (2008b)	0.0000000622	CCME (2008b)	2.02E-02	USEPA (1996)	0.00249	CCME (2008b)		
Indeno[1,2,3-c,d]pyrene	1,584,893	CCME (2008b)	0.0000677	CCME (2008b)	1.90E-02	USEPA (1996)	0.000022	CCME (2008b)		
Halogenated Aliphatics										
Vinyl chloride	18.6	USEPA (1996)	1.11	USEPA (1996)	1.06E-01	USEPA (1996)	2760	USEPA (1996)		
1,1-Dichloroethene	65	USEPA (1996)	1.07	USEPA (1996)	1.04E-01	USEPA (1996)	2250	USEPA (1996)		
Trichloroethene (Trichloroethylene, TCE)	94	USEPA (1996)	0.422	USEPA (1996)	7.90E-02	USEPA (1996)	1100	USEPA (1996)	2.19	CCME (2006d)
Tetrachloroethene (Tetrachloroethylene, Perchloroethylene, PCE)	265	USEPA (1996)	0.754	USEPA (1996)	7.20E-02	USEPA (1996)	200	USEPA (1996)		
1,2-Dichloroethane	38	USEPA (1996)	0.0401	USEPA (1996)	1.04E-01	USEPA (1996)	8520	USEPA (1996)		
Dichloromethane (Methylene chloride)	23.74	ORNL (2006)	0.133	ORNL (2006)	1.01E-01	ORNL (2006)	1300	ORNL (2006)		
Trichloromethane (Chloroform)	53.0	USEPA (1996)	0.15	USEPA (1996)	1.04E-01	USEPA (1996)	7920	USEPA (1996)		
Tetrachloromethane (Carbon tetrachloride)	152	USEPA (1996)	1.25	USEPA (1996)	7.80E-02	USEPA (1996)	793	USEPA (1996)		
Dibromochloromethane	35	ORNL (2006)	0.032	ORNL (2006)	1.96E-02	ORNL (2006)	2700	ORNL (2006)		
Chlorinated Aromatics										
Chlorobenzene	224	USEPA (1996)	0.152	USEPA (1996)	7.30E-02	USEPA (1996)	472	USEPA (1996)		
1,2-Dichlorobenzene	379	USEPA (1996)	0.0779	USEPA (1996)	6.90E-02	USEPA (1996)	156	USEPA (1996)		
1,3-Dichlorobenzene	434	ORNL (2006)	0.108	ORNL (2006)			125	ORNL (2006)		
1,4-Dichlorobenzene	616	USEPA (1996)	0.0996	USEPA (1996)	6.90E-02	USEPA (1996)	73.8	USEPA (1996)		
1,2,3-Trichlorobenzene	No data, assumed to be equal to other trichlorobenzene isomers									
1,2,4-Trichlorobenzene	1,659	USEPA (1996)	0.0582	USEPA (1996)	3.00E-02	USEPA (1996)	49	ORNL (2006)		
1,3,5-Trichlorobenzene	No data, assumed to be equal to other trichlorobenzene isomers									
1,2,3,4-Tetrachlorobenzene	No data, assumed to be equal to other tetrachlorobenzene isomers									
1,2,3,5-	No data, assumed to be equal to other tetrachlorobenzene isomers									

Table C-6. Chemical Parameters

	K_{oc} ml/g	Source	H' dimensionless	Source	D_a cm^2/s	Source	Solubility mg/L	Source	Half Life yr	Source
Tetrachlorobenzene										
1,2,4,5-Tetrachlorobenzene	1,186	ORNL (2006)	0.0409	ORNL (2006)	2.11E-02	ORNL (2006)	0.595	ORNL (2006)		
Pentachlorobenzene	32,148	USEPA (1996)	0.0287	ORNL (2006)	5.70E-02	ORNL (2006)	0.831	ORNL (2006)		
Hexachlorobenzene	80,000	USEPA (1996)	0.0541	USEPA (1996)	5.42E-02	USEPA (1996)	6.2	USEPA (1996)		
Dichlorophenol	718	ORNL (2006)	0.0000895	ORNL (2006)	3.46E-02	ORNL (2006)	4500	ORNL (2006)		
Trichlorophenol	1,186	ORNL (2006)	0.0000662	ORNL (2006)	2.91E-02	ORNL (2006)	1200	ORNL (2006)		
Tetrachlorophenol	2,002	ORNL (2006)	0.000361	ORNL (2006)	2.17E-02	ORNL (2006)	23	ORNL (2006)		
Pentachlorophenol	2,500	ORNL (2006)	1.00E-06	ORNL (2006)	5.60E-02	ORNL (2006)	14	ORNL (2006)		
Dioxins & Furans [2]										
PCBs [2]										
Pesticides										
Aldicarb	32	ORNL (2006)	5.39E-05	ORNL (2006)	3.05E-02	ORNL (2006)	6030	ORNL (2006)		
Aldrin	106,000	ORNL (2006)	0.0018	ORNL (2006)	1.32E-02	ORNL (2006)	0.017	ORNL (2006)		
Atrazine	230	ORNL (2006)	9.65E-08	ORNL (2006)			35	ORNL (2006)		
Azinphos-methyl	231	SRC (2006) [1]	9.96E-07	SRC (2006)			20.9	SRC (2006)		
Bendiocarb	21	SRC (2006) [1]	1.63E-06	SRC (2006)			260	SRC (2006)		
Bromoxynil	435	ORNL (2006)	5.40E-09	ORNL (2006)	2.01E-02	ORNL (2006)	130	ORNL (2006)		
Carbaryl	242	ORNL (2006)	1.78E-07	ORNL (2006)	2.78E-02	ORNL (2006)	110	ORNL (2006)		
Carbofuran	71	ORNL (2006)	1.26E-07	ORNL (2006)			320	ORNL (2006)		
Chlorothalonil	2,392	ORNL (2006)	8.18E-05	ORNL (2006)			0.6	ORNL (2006)		
Chlorpyrifos	6,829	ORNL (2006)	0.00012	ORNL (2006)			1.12	ORNL (2006)		
Cyanazine	124	ORNL (2006)	1.21E-10	ORNL (2006)			170	ORNL (2006)		
2,4-D	29	ORNL (2006)	1.45E-06	ORNL (2006)	2.31E-02	ORNL (2006)	677	ORNL (2006)		
DDT	794,328	EC (1999a)	3.40E-04	ORNL (2006)	1.37E-02	ORNL (2006)	0.0055	ORNL (2006)		
Diazinon	1,337	ORNL (2006)	4.62E-06	ORNL (2006)	2.06E-02	ORNL (2006)	40	ORNL (2006)		
Dicamba	29	ORNL (2006)	8.91E-08	ORNL (2006)			8310	ORNL (2006)		
Dichlofop-methyl	17,092	SRC (2006) [1]	8.21E-05	SRC (2006)			0.8	SRC (2006)		
Dieldrin	10,600	ORNL (2006)	0.000409	ORNL (2006)	1.25E-02	ORNL (2006)	0.25	ORNL (2006)		
Dimethoate	25	ORNL (2006)	4.29E-09	ORNL (2006)			25000	ORNL (2006)		

Table C-6. Chemical Parameters

	K_{oc} ml/g	Source	H' dimensionless	Source	D_a cm^2/s	Source	Solubility mg/L	Source	Half Life yr	Source
Dinoseb	3,544	ORNL (2006)	1.86E-05	ORNL (2006)			52	ORNL (2006)		
Diquat	1,933	ORNL (2006)	5.81E-12	ORNL (2006)			708000	ORNL (2006)		
Diuron	136	ORNL (2006)	2.06E-08	ORNL (2006)			42	ORNL (2006)		
Endosulfan	22,000	ORNL (2006)	0.00266	ORNL (2006)	1.15E-02	ORNL (2006)	0.45	ORNL (2006)		
Endrin	10,811	USEPA (1996)	0.000308	USEPA (1996)	1.25E-02	USEPA (1996)	0.25	USEPA (1996)		
Glyphosate	19	ORNL (2006)	1.67E-17	ORNL (2006)	4.37E-02	ORNL (2006)	12000	ORNL (2006)		
Heptachlor epoxide	9,528	USEPA (1996)	0.0447	USEPA (1996)	1.12E-02	USEPA (1996)	0.18	USEPA (1996)		
Lindane	1,352	USEPA (1996)	0.000574	USEPA (1996)	1.42E-02	USEPA (1996)	6.8	USEPA (1996)		
Linuron	350	ORNL (2006)	2.56E-07	ORNL (2006)			75	ORNL (2006)		
Malathion	31	ORNL (2006)	2.00E-07	ORNL (2006)			143	ORNL (2006)		
MCPA	29	ORNL (2006)	5.44E-08	ORNL (2006)			630	ORNL (2006)		
Methoxychlor	80,000	USEPA (1996)	0.000648	USEPA (1996)	1.56E-02	USEPA (1996)	0.045	USEPA (1996)		
Metolachlor	292	ORNL (2006)	3.68E-07	ORNL (2006)			530	ORNL (2006)		
Metribuzin	1,196	ORNL (2006)	4.78E-09	ORNL (2006)			1050	ORNL (2006)		
Paraquat (as dichloride)	1,405	ORNL (2006)	1.32E-11	ORNL (2006)			620000	ORNL (2006)		
Parathion	1,779	ORNL (2006)	1.22E-05	ORNL (2006)	1.70E-02	ORNL (2006)	11	ORNL (2006)		
Phorate	444	ORNL (2006)	0.000179	ORNL (2006)			50	ORNL (2006)		
Picloram	18	ORNL (2006)	2.18E-12	ORNL (2006)			430	ORNL (2006)		
Simazine	149	ORNL (2006)	3.85E-08	ORNL (2006)			6.2	ORNL (2006)		
Tebuthiuron	23	ORNL (2006)	4.91E-09	ORNL (2006)			2500	ORNL (2006)		
Terbufos	979	ORNL (2006)	0.000981	ORNL (2006)			5.07	ORNL (2006)		
Toxaphene	95,816	USEPA (1996)	0.000246	USEPA (1996)	1.16E-02	USEPA (1996)	0.74	USEPA (1996)		
Triallate	1,641	ORNL (2006)	0.000789	ORNL (2006)			4	ORNL (2006)		
Trifluarin	9,682	ORNL (2006)	0.00421	ORNL (2006)	1.49E-02	ORNL (2006)	0.184	ORNL (2006)		
Other Organics										
Aniline	45	ORNL (2006)	8.26E-05	ORNL (2006)	7.00E-02	ORNL (2006)	36000	ORNL (2006)		
Bis(2-ethyl-hexyl)phthalate	111,123	USEPA (1996)	4.18E-06	USEPA (1996)	3.51E-02	USEPA (1996)	0.34	USEPA (1996)		
Bis(Chloro-methyl)ether	76	USEPA (1996)	0.000738	USEPA (1996)	6.92E-02	USEPA (1996)	0.000172	USEPA (1996)		
Dibutyl phthalate	1,460	ORNL (2006)	0.000074	ORNL (2006)	4.38E-02	ORNL (2006)	11.2	ORNL (2006)		
Dichlorobenzidine	7,489	ORNL (2006)	2.09E-09	ORNL (2006)	1.94E-02	ORNL (2006)	3.1	ORNL (2006)		

Table C-6. Chemical Parameters

	K_{oc} ml/g	Source	H' dimensionless	Source	D_a cm^2/s	Source	Solubility mg/L	Source	Half Life yr	Source
Diisopropanolamine	*** 2.2	CCME (2006b)	7.00E-06	CCME (2006b)			870000	CCME (2006b)		
Ethylene glycol	0.0072	EC (1999b)	2.50E-06	EC (1999b)	0.108	ORNL (2006)	1000000	EC (1999b)		
Hexachlorobutadiene	994	ORNL (2006)	0.421	ORNL (2006)	5.61E-02	ORNL (2006)	3.2	ORNL (2006)		
Methylmethacrylate	10	ORNL (2006)	0.0138	ORNL (2006)	7.70E-02	ORNL (2006)	15000	ORNL (2006)		
MTBE	12	USEPA (1994)	0.023	USEPA (1994)	1.02E-01	ORNL (2006)	51000	USEPA (1994)		
Nonylphenol	141,254	EC (2002)	0.005	EC (2002)			5.43	EC (2002)		
Phenol	12	CCME (1999)	1.60E-05	CCME (1999)	0.082	ORNL (2006)	87,000	CCME (1999)		
Sulfolane	1.2	CCME (2006c)	3.60E-08	CCME (2006c)			1000000	CCME (2006c)		

Notes

K_{oc} = organic carbon water partition coefficient

H' = dimensionless Henry's Law Coefficient

D_{air} = diffusion coefficient in air

na = not applicable or not available

****Value presented is a mean K_d rather than a K_{oc} since diisopropanolamine sorbs to clays in preference to organic carbon.*

1. Calculated using the equation $K_{oc} = 0.41xK_{ow}$

2. PCBs, dioxins and furans are groups of chemicals with a wide range of chemical properties. Chemical properties are not provided for these groups.

CCME (1999) refers to the Canadian Environmental Quality Guidelines (CEQG) and updates, including the scientific supporting documents that are summarized in the CEQG.

Table C-7. Human Toxicity Reference Values

	Non Carcinogenic TRV				Carcinogenic TRV			
	Oral TDI mg/kg-d	Source	Inhalation TC mg/m^3	Source	Oral SF $(mg/kg\text{-}d)^{-1}$	Source	Inhalation UR $(mg/m^3)^{-1}$	Source
Metals								
Arsenic (inorganic)					2.8	HC (2004b)	6.4	HC (2004b)
Barite-barium	0.07							
Hydrocarbons								
Benzene					0.31	HC (2004b)	0.0033	HC (2004b)
Toluene	0.22	HC (2004b)	3.8	HC (2004b)				
Ethylbenzene	0.1	US EPA (2006)	1.0	US EPA (2006)				
Xylenes	1.5	HC (2004b)	0.18	HC (2004b)				
Styrene	0.12	HC (2004b)	0.092	HC (2004b)				
Aliphatic C_6-C_8	5.0	CCME (2008a)	18.4	CCME (2008a)				
Aliphatic $C_{>8}$-C_{10}	0.1	CCME (2008a)	1.0	CCME (2008a)				
Aliphatic $C_{>10}$-C_{12}	0.1	CCME (2008a)	1.0	CCME (2008a)				
Aliphatic $C_{>12}$-C_{16}	0.1	CCME (2008a)	1.0	CCME (2008a)				
Aliphatic $C_{>16}$-C_{21}	2.0	CCME (2008a)						
Aliphatic $C_{>21}$-C_{34}	2.0	CCME (2008a)						
Aliphatic $C_{>34}$	20	CCME (2008a)						
Aromatic $C_{>8}$-C_{10}	0.04	CCME (2008a)	0.2	CCME (2008a)				
Aromatic $C_{>10}$-C_{12}	0.04	CCME (2008a)	0.2	CCME (2008a)				
Aromatic $C_{>12}$-C_{16}	0.04	CCME (2008a)	0.2	CCME (2008a)				
Aromatic $C_{>16}$-C_{21}	0.03	CCME (2008a)						
Aromatic $C_{>21}$-C_{34}	0.03	CCME (2008a)						
Aromatic $C_{>34}$	0.03	CCME (2008a)						
Naphthalene	0.02	US EPA (2006)	0.003	US EPA (2006)				
Acenaphthene	0.06	US EPA (2006)	0.27	see note 1				
Fluorene	0.04	US EPA (2006)	0.18	see note 1				
Fluoranthene	0.04	US EPA (2006)	0.18	see note 1				
Anthracene	0.3	US EPA (2006)	1.34	see note 1				

Table C-7. Human Toxicity Reference Values

	Non Carcinogenic TRV				Carcinogenic TRV			
	Oral TDI mg/kg-d	Source	Inhalation TC mg/m^3	Source	Oral SF $(mg/kg\text{-}d)^{-1}$	Source	Inhalation UR $(mg/m^3)^{-1}$	Source
Pyrene	0.03	US EPA (2006)	0.13	see note 1				
Benzo(a)pyrene					2.3	CCME (2008b)		
Halogenated Aliphatics								
Vinyl chloride	0.003	US EPA (2006)	0.1	US EPA (2006)	0.26	HC (2004b)	0.0088	US EPA (2006)
1,1-Dichloroethene	0.05	HC (2004b)	0.2	US EPA (2006)				
Trichloroethene (Trichloroethylene, TCE)	0.00146	CCME (2006d)	0.04	CCME (2006d)	0.00025	CCME (2006d)	0.00061	CCME (2006d)
Tetrachloroethene (Tetrachloroethylene, Perchloroethylene, PCE)	0.014	HC (2004b)	0.36	HC (2004b)				
1,2-Dichloroethane					0.00806	HC (2004b)	0.026	US EPA (2006)
Dichloromethane (Methylene chloride)	0.05	HC (2004b)	3	ORNL (2006)	0.000079	HC (2004b)	0.000023	HC (2004b)
Trichloromethane (Chloroform)	0.01	US EPA (2006)	0.04475	see note 1			0.023	US EPA (2006)
Tetrachloromethane (Carbon tetrachloride)	0.0007	US EPA (2006)	0.00313	see note 1	0.13	US EPA (2006)	0.015	US EPA (2006)
Dibromochloromethane	0.02	US EPA (2006)	0.08949	see note 1				
Chlorinated Aromatics								
Chlorobenzene	0.43	HC (2004b)	0.01	HC (2004b)				
1,2-Dichlorobenzene	0.43	HC (2004b)	1.92411	see note 1				
1,4-Dichlorobenzene	0.11	HC (2004b)	0.095	HC (2004b)				
1,2,3-Trichlorobenzene	0.0015	HC (2004b)	0.00671	see note 1				
1,2,4-Trichlorobenzene	0.0016	HC (2004b)	0.007	HC (2004b)				
1,3,5-Trichlorobenzene	0.0015	HC (2004b)	0.0036	HC (2004b)				
1,2,3,4-Tetrachlorobenzene	0.0034	HC (2004b)	0.01521	see note 1				
1,2,3,5-Tetrachlorobenzene	0.00041	HC (2004b)	0.00183	see note 1				
1,2,4,5-Tetrachlorobenzene	0.00021	HC (2004b)	0.00094	see note 1				
Pentachlorobenzene	0.001	HC (2004b)	0.00447	see note 1				

Table C-7. Human Toxicity Reference Values

	Non Carcinogenic TRV				Carcinogenic TRV			
	Oral TDI mg/kg-d	**Source**	**Inhalation TC mg/m^3**	**Source**	**Oral SF $(mg/kg\text{-}d)^{-1}$**	**Source**	**Inhalation UR $(mg/m^3)^{-1}$**	**Source**
Hexachlorobenzene	0.0005	HC (2004b)	0.002237	see note 1	0.83	HC (2004b)	0.1855	see note 1
2,4-Dichlorophenol	0.1	HC (2004b)	0.447468	see note 1				
2,4,6-Trichlorophenol					0.02	HC (2004b)	0.0045	see note 1
2,3,4,6-Tetrachlorophenol	0.01	HC (2004b)	0.04475	see note 1				
Pentachlorophenol	0.006	HC (2004b)	0.02685	see note 1				
Dioxins and Furans	2.00E-09	HC (2004b)						
PCBs	0.001	HC (2004b)						
Pesticides								
Aldicarb	0.001	HC (2004b)						
Aldrin and dieldrin	0.0001	HC (2004b)						
Atrazine and metabolites	0.0005	HC (2004b)						
Azinphos-methyl	0.0025	HC (2004b)						
Bendiocarb	0.004	HC (2004b)						
Bromoxynil	0.0005	HC (2004b)						
Carbaryl	0.01	HC (2004b)						
Carbofuran	0.01	HC (2004b)						
Chlorothalonil	0.015	US EPA (2006)						
Chlorpyrifos	0.01	HC (2004b)						
Cyanazine	0.0013	HC (2004b)						
2,4-D	0.01	HC (2004b)						
DDT	0.01	HC (2004b)						
Diazinon	0.002	HC (2004b)						
Dicamba	0.0125	HC (2004b)						
Dichlofop-methyl	0.001	HC (2004b)						
Dieldrin (see Aldrin and Dieldrin)								
Dimethoate	0.002	HC (2004b)						
Dinoseb	0.001	HC (2004b)						

Table C-7. Human Toxicity Reference Values

	Non Carcinogenic TRV				Carcinogenic TRV			
	Oral TDI mg/kg-d	Source	Inhalation TC mg/m^3	Source	Oral SF $(mg/kg\text{-}d)^{-1}$	Source	Inhalation UR $(mg/m^3)^{-1}$	Source
Diquat	0.008	HC (2004b)						
Diuron	0.0156	HC (2004b)						
Endosulfan	6.00E-03	US EPA (2006)						
Endrin	3.00E-04	US EPA (2006)						
Glyphosate	0.03	HC (2004b)						
Heptachlor epoxide	1.30E-05	US EPA (2006)			9.1	US EPA (2006)	2.6	US EPA (2006)
Lindane	3.00E-04	US EPA (2006)						
Linuron	2.00E-03	US EPA (2006)						
Malathion	0.02	HC (2004b)						
MCPA	5.00E-04	US EPA (2006)						
Methoxychlor	0.1	HC (2004b)						
Metolachlor	0.005	HC (2004b)						
Metribuzin	0.0083	HC (2004b)						
Paraquat (as dichloride)	0.001	HC (2004b)						
Parathion	0.005	HC (2004b)						
Phorate	0.0002	HC (2004b)						
Picloram	0.02	HC (2004b)						
Simazine	0.0013	HC (2004b)						
Tebuthiuron	7.00E-02	US EPA (2006)						
Terbufos	0.00005	HC (2004b)						
Toxaphene					1.1	US EPA (2006)	0.32	US EPA (2006)
Triallate	1.30E-02	US EPA (2006)						
Trifluarin	0.0048	HC (2004b)						
Other Organics								
Aniline	0.007	HC (2004b)	0.0313	see note 1				
Bis(2-ethyl-hexyl)phthalate	0.044	HC (2004b)	0.1969	see note 1				
Dibutyl phthalate	0.063	HC (2004b)	0.28191	see note 1				

Table C-7. Human Toxicity Reference Values

	Non Carcinogenic TRV				Carcinogenic TRV			
	Oral TDI mg/kg-d	Source	Inhalation TC mg/m^3	Source	Oral SF (mg/kg-d)$^{-1}$	Source	Inhalation UR (mg/m^3)$^{-1}$	Source
Dichlorobenzidine					0.0676	HC (2004b)	0.015107214	see note 1
Diisopropanolamine	0.39	CCME (2006b)						
Ethylene glycol	2	US EPA (2006)	8.94937	see note 1				
Hexachlorobutadiene					0.078	US EPA (2006)	0.022	US EPA (2006)
Methylmethacrylate	0.05	HC (2004b)	0.052	HC (2004b)				
MTBE	0.01	HC (2004b)	0.037	HC (2004b)				
Nonylphenol								
Phenol	0.06	HC (2004b)	0.26848	see note 1				
Sulfolane	0.0097	CCME (2006c)						

Notes:
TRV = toxicity reference value
TDI = tolerable daily intake
TC = tolerable concentration
SF = slope factor
UR = unit risk
1. estimated from the oral TDI assuming an adult body weight of 70.7 kg, and an inhalation rate of 15.8 m^3/d
CCME (1999) refers to the Canadian Environmental Quality Guidelines (CEQG) and updates, including the scientific supporting documents that are summarized in the CEQG.
HC = Health Canada

Table C-8. Human Absorption Factors

	Absorption Factors					
	Gut	Source	Skin	Source	Lung	Source
Metals						
Arsenic (inorganic)	1.00		0.03	HC (2004a)	1.00	
Barite-barium	1.00		1.00		1.00	
Hydrocarbons						
Benzene	1.00		0.08	HC (2004a)	1.00	
Toluene	1.00		0.12	HC (2004a)	1.00	
Ethylbenzene	1.00		0.20	HC (2004a)	1.00	
Xylenes	1.00		0.12	HC (2004a)	1.00	
Styrene	1.00		0.20	CCME (2008a)	1.00	
Aliphatic C_6-C_8	1.00		0.20	CCME (2008a)	1.00	
Aliphatic $C_{>8}$-C_{10}	1.00		0.20	CCME (2008a)	1.00	
Aliphatic $C_{>10}$-C_{12}	1.00		0.20	CCME (2008a)	1.00	
Aliphatic $C_{>12}$-C_{16}	1.00		0.20	CCME (2008a)	1.00	
Aliphatic $C_{>16}$-C_{21}	1.00		0.20	CCME (2008a)	1.00	
Aliphatic $C_{>21}$-C_{34}	1.00		0.20	CCME (2008a)	1.00	
Aliphatic $C_{>34}$	1.00		0.20	CCME (2008a)	1.00	
Aromatic $C_{>8}$-C_{10}	1.00		0.20	CCME (2008a)	1.00	
Aromatic $C_{>10}$-C_{12}	1.00		0.20	CCME (2008a)	1.00	
Aromatic $C_{>12}$-C_{16}	1.00		0.20	CCME (2008a)	1.00	
Aromatic $C_{>16}$-C_{21}	1.00		0.20	CCME (2008a)	1.00	
Aromatic $C_{>21}$-C_{34}	1.00		0.20	CCME (2008a)	1.00	
Aromatic $C_{>34}$	1.00		0.20	CCME (2008a)	1.00	
Naphthalene	1.00		0.10	CCME (1999)	1.00	
Acenaphthene	1.00		0.20	CCME (2008a)	1.00	
Fluorene	1.00		0.20	CCME (2008a)	1.00	
Fluoranthene	1.00		0.20	CCME (2008a)	1.00	
Anthracene	1.00		0.29	CCME (2008a)	1.00	
Pyrene	1.00		0.20	CCME (2008a)	1.00	
Benzo(a)pyrene	1.00		0.34	CCME (2008b)	1.00	
Halogenated Aliphatics						
Vinyl chloride	1.00		0.16	HC (2004a)	1.00	

Table C-8. Human Absorption Factors

	Absorption Factors					
	Gut	Source	Skin	Source	Lung	Source
1,1-Dichloroethene	1.00		0.10	HC (2004a)	1.00	
Trichloroethene (Trichloroethylene, TCE)	1.00		0.10	HC (2004a)	1.00	
Tetrachloroethene (Tetrachloroethylene, Perchloroethylene, PCE)	1.00		0.10	HC (2004a)	1.00	
1,2-Dichloroethane	1.00		0.10	HC (2004a)	1.00	
Dichloromethane (Methylene chloride)	1.00		1.00		1.00	
Trichloromethane (Chloroform)	1.00		0.10	HC (2004a)	1.00	
Tetrachloromethane (Carbon tetrachloride)	1.00		0.10	HC (2004a)	1.00	
Dibromochloromethane	1.00		0.10	HC (2004a)	1.00	
Chlorinated Aromatics						
Chlorobenzene	1.00		0.10	HC (2004a)	1.00	
1,2-Dichlorobenzene	1.00		0.10	HC (2004a)	1.00	
1,4-Dichlorobenzene	1.00		0.10	HC (2004a)	1.00	
1,2,3-Trichlorobenzene	1.00		0.08	HC (2004a)	1.00	
1,2,4-Trichlorobenzene	1.00		0.08	HC (2004a)	1.00	
1,3,5-Trichlorobenzene	1.00		0.08	HC (2004a)	1.00	
1,2,3,4-Tetrachlorobenzene	1.00		1.00		1.00	
1,2,3,5-Tetrachlorobenzene	1.00		1.00		1.00	
1,2,4,5-Tetrachlorobenzene	1.00		1.00		1.00	
Pentachlorobenzene	1.00		1.00		1.00	
Hexachlorobenzene	1.00		0.13	HC (2004a)	1.00	
Dichlorophenol	1.00		1.00		1.00	
Trichlorophenol	1.00		1.00		1.00	
Tetrachlorophenol	1.00		1.00		1.00	
Pentachlorophenol	1.00		0.11	HC (2004a)	1.00	
Dioxins and Furans	1.00		1.00		1.00	
PCBs	1.00		1.00		1.00	
Pesticides						
Aldicarb	1.00		1.00		1.00	
Aldrin and dieldrin	1.00		0.25	HC (2004a)	1.00	
Atrazine and metabolites	1.00		1.00		1.00	

Table C-8. Human Absorption Factors

	Absorption Factors					
	Gut	Source	Skin	Source	Lung	Source
Azniphos-methyl	1.00		1.00		1.00	
Bendiocarb	1.00		1.00		1.00	
Bromoxynil	1.00		1.00		1.00	
Carbaryl	1.00		1.00		1.00	
Carbofuran	1.00		1.00		1.00	
Chlorothalonil	1.00		1.00		1.00	
Chlorpyrifos	1.00		1.00		1.00	
Cyanazine	1.00		1.00		1.00	
2,4-D	1.00		1.00		1.00	
DDT	1.00		1.00		1.00	
Diazinon	1.00		1.00		1.00	
Dicamba	1.00		1.00		1.00	
Dichlofop-methyl	1.00		1.00		1.00	
Dieldrin (see Aldrin and Dieldrin)	1.00		1.00		1.00	
Dimethoate	1.00		1.00		1.00	
Dinoseb	1.00		1.00		1.00	
Diquat	1.00		1.00		1.00	
Diuron	1.00		1.00		1.00	
Endosulfan	1.00		0.20	HC (2004a)	1.00	
Endrin	1.00		0.25	HC (2004a)	1.00	
Glyphosate	1.00		1.00		1.00	
Heptachlor epoxide	1.00		0.20	HC (2004a)	1.00	
Lindane	1.00		1.00		1.00	
Linuron	1.00		1.00		1.00	
Malathion	1.00		1.00		1.00	
MCPA	1.00		1.00		1.00	
Methoxychlor	1.00		0.20	HC (2004a)	1.00	
Metolachlor	1.00		1.00		1.00	
Metribuzin	1.00		1.00		1.00	
Paraquat (as dichloride)	1.00		1.00		1.00	
Parathion	1.00		1.00		1.00	

Table C-8. Human Absorption Factors

	Absorption Factors					
	Gut	Source	Skin	Source	Lung	Source
Phorate	1.00		1.00		1.00	
Picloram	1.00		1.00		1.00	
Simazine	1.00		1.00		1.00	
Tebuthiuron	1.00		1.00		1.00	
Terbufos	1.00		1.00		1.00	
Toxaphene	1.00		1.00		1.00	
Triallate	1.00		1.00		1.00	
Trifluarin	1.00		1.00		1.00	
Other Organics						
Aniline	1.00		1.00		1.00	
Bis(2-ethyl-hexyl)phthalate	1.00		0.02	HC (2004a)	1.00	
Bis(Chloro-methyl)ether	1.00		1.00		1.00	
Dibutyl phthalate	1.00		1.00		1.00	
Dichlorobenzidine	1.00		0.54	HC (2004a)	1.00	
Diisopropanolamine	1.00		0.25	CCME (2006b)	1.00	
Ethylene glycol	1.00		1.00		1.00	
Hexachlorobutadiene	1.00		0.20	HC (2004a)	1.00	
Methylmethacrylate	1.00		1.00		1.00	
MTBE	1.00		0.10	HC (2004a)	1.00	
Nitriloacetic acid	1.00		1.00		1.00	
Nonylphenol	1.00		1.00		1.00	
Phenol	1.00		0.26	HC (2004a)	1.00	
Sulfolane	1.00		1.00		1.00	
Trihalomethanes - total (THMs)	1.00		1.00		1.00	

Notes:

Sources only provided where an absorption factor other than 1.0 is used.

CCME (1999) refers to the Canadian Environmental Quality Guidelines (CEQG) and updates, including the scientific supporting documents that are summarized in the CEQG.

HC = Health Canada

Table C-9. Human Background Exposure Parameters

	Toddler EDI mg/kg-d	Adult EDI mg/kg-d	Source	C_a mg/m^3	Source	BSC mg/kg	Source	SAF
Metals								
Arsenic (inorganic)	na	na	CCME (1999)	na	CCME (1999)	10	CCME (1999)	0.2
Barite-barium	0.014	0.014	AENV 2004	na	AENV 2004	325	AENV 2004	0.25
Hydrocarbons								
Benzene	na	na	-	na	-	0	assumed	na
Toluene	0.0028	0.0028	EC (2004b)	0.0442	EC (2004b)	0	assumed	0.5
Ethylbenzene	0.0029	0.0029	EC (2004b)	0.0075	EC (2004b)	0	assumed	0.5
Xylenes	0.0079	0.0079	EC (2004b)	0.00182	EC (2004b)	0	assumed	0.5
Styrene	0.00071	0.00027	PSL	0.00028	PSL	0	assumed	0.5
Aliphatic C_6-C_8	0.02334	0.02334	CCME (2008a)	0.09111	CCME (2008a)	0	assumed	0.5
Aliphatic $C_{>8}$-C_{10}	0.0103	0.0103	CCME (2008a)	0.03881	CCME (2008a)	0	assumed	0.5
Aliphatic $C_{>10}$-C_{12}	0	0	CCME (2008a)	0	CCME (2008a)	0	assumed	0.5
Aliphatic $C_{>12}$-C_{16}	0	0	CCME (2008a)	0	CCME (2008a)	0	assumed	0.5
Aliphatic $C_{>16}$-C_{21}	0	0	CCME (2008a)	0	CCME (2008a)	0	assumed	0.6
Aliphatic $C_{>21}$-C_{34}	0	0	CCME (2008a)	0	CCME (2008a)	0	assumed	0.6
Aliphatic $C_{>34}$	0	0	CCME (2008a)	0	CCME (2008a)	0	assumed	0.8
Aromatic $C_{>8}$-C_{10}	0.00938	0.00938	CCME (2008a)	0.03745	CCME (2008a)	0	assumed	0.5
Aromatic $C_{>10}$-C_{12}	0	0	CCME (2008a)	0	CCME (2008a)	0	assumed	0.5
Aromatic $C_{>12}$-C_{16}	0	0	CCME (2008a)	0	CCME (2008a)	0	assumed	0.5
Aromatic $C_{>16}$-C_{21}	0	0	CCME (2008a)	0	CCME (2008a)	0	assumed	0.6
Aromatic $C_{>21}$-C_{34}	0	0	CCME (2008a)	0	CCME (2008a)	0	assumed	0.6
Aromatic $C_{>34}$	0	0	CCME (2008a)	0	CCME (2008a)	0	assumed	0.8
Naphthalene	0.00053545	0.00021231	ATSDR (2005)	0.00095	ATSDR (2005)	0	assumed	0.5
Acenaphthene	0	0	assumed	0	assumed	0	assumed	0.5
Fluorene	0.00902	0.00358	ATSDR (1995)	0.016	ATSDR (1995)	0	assumed	0.5
Fluoranthene	0	0	assumed	0	assumed	0	assumed	0.5
Anthracene	0.00502	0.00199	ATSDR (1995)	0.0089	ATSDR (1995)	0	assumed	0.5
Pyrene	0.00620	0.00246	ATSDR (1995)	0.011	ATSDR (1995)	0	assumed	0.5
Benzo(a)pyrene	na	na	-	na	-	0.07	CCME (2008b)	na
Halogenated Aliphatics								
Vinyl chloride	0	0	assumed	0	assumed	0	assumed	0.2

Table C-9. Human Background Exposure Parameters

	Toddler EDI mg/kg-d	Adult EDI mg/kg-d	Source	C_a mg/m^3	Source	BSC mg/kg	Source	SAF
1,1-Dichloroethene	0	0	assumed	0	assumed	0	assumed	0.2
Trichloroethene (Trichloroethylene)	0.00053	0.00041	CCME (2006d)	0.0014	CCME (2006d)	0	assumed	0.2
Tetrachloroethene (Tetrachloroethylene, Perchloroethylene, PCE)	0	0	assumed	0	assumed	0	assumed	0.2
1,2-Dichloroethane	0.0006	0.0005	PSL	0.0018	PSL	0	assumed	0.2
Dichloromethane (Methylene chloride)	0.00558	0.00471	PSL	0.0063	PSL	0	assumed	0.2
Trichloromethane (Chloroform)	0.004315	0.00361	PSL	0.0063	PSL	0	assumed	0.2
Tetrachloromethane (Carbon tetrachloride)	0	0	assumed	0	assumed	0	assumed	0.2
Dibromochloromethane	0	0	assumed	0	assumed	0	assumed	0.2
Chlorinated Aromatics								
Chlorobenzene	0.000122	0.000066	PSL	0.00016	PSL	0	assumed	0.2
1,2-Dichlorobenzene	0.00004	0.00003	PSL	0.1	PSL	0	assumed	0.2
1,4-Dichlorobenzene	0.0014	0.0009	PSL	0.0028	PSL	0	assumed	0.2
1,2,3-Trichlorobenzene	0.00023	0.00024	PSL	0.0008	PSL	0	assumed	0.2
1,2,4-Trichlorobenzene	0.0006	0.00045	PSL	0.0018	PSL	0	assumed	0.2
1,3,5-Trichlorobenzene	0.00032	0.00025	PSL	0.0008	PSL	0	assumed	0.2
1,2,3,4-Tetrachlorobenzene	0.0000007	0.00000025	PSL	0.00000017	PSL	0	assumed	0.2
1,2,3,5-Tetrachlorobenzene	0.00000045	0.00000015	PSL	0.00000017	PSL	0	assumed	0.2
1,2,4,5-Tetrachlorobenzene	0.0000007	0.0000002	PSL	0.00000017	PSL	0	assumed	0.2
Pentachlorobenzene	0.000002	0.0000005	PSL	0.0000001	PSL	0	assumed	0.2
Hexachlorobenzene	0.0000178	0.0000028	PSL	0.00000015	PSL	0	assumed	0.2
2,4-Dichlorophenol	0	0	assumed	0	assumed	0	assumed	0.2
2,4,6-Trichlorophenol	0	0	assumed	0	assumed	0	assumed	0.2
2,3,4,6-Tetrachlorophenol	0	0	assumed	0	assumed	0	assumed	0.2
Pentachlorophenol	0	0	assumed	0	assumed	0	assumed	0.2
Dioxins and Furans	7.1E-09	1.33E-09	EC (2000)	0	assumed	0	assumed	0.25
PCBs	7.6925E-06	0.00000254	EC (2001)	0	assumed	0	assumed	0.2
Pesticides								
Aldicarb	0	0	assumed	0	assumed	0	assumed	0.2
Aldrin and dieldrin	0	0	assumed	0	assumed	0	assumed	0.2

Table C-9. Human Background Exposure Parameters

	Toddler EDI mg/kg-d	Adult EDI mg/kg-d	Source	C_a mg/m^3	Source	BSC mg/kg	Source	SAF
Atrazine and metabolites	0	0	assumed	0	assumed	0	assumed	0.2
Azinphos-methyl	0	0	assumed	0	assumed	0	assumed	0.2
Bendiocarb	0	0	assumed	0	assumed	0	assumed	0.2
Bromoxynil	0	0	assumed	0	assumed	0	assumed	0.2
Carbaryl	0	0	assumed	0	assumed	0	assumed	0.2
Carbofuran	0	0	assumed	0	assumed	0	assumed	0.2
Chlorothalonil	0	0	assumed	0	assumed	0	assumed	0.2
Chlorpyrifos	0	0	assumed	0	assumed	0	assumed	0.2
Cyanazine	0	0	assumed	0	assumed	0	assumed	0.2
2,4-D	0	0	assumed	0	assumed	0	assumed	0.2
DDT	0	0	assumed	0	assumed	0	assumed	0.2
Diazinon	0	0	assumed	0	assumed	0	assumed	0.2
Dicamba	0	0	assumed	0	assumed	0	assumed	0.2
Dichlofop-methyl	0	0	assumed	0	assumed	0	assumed	0.2
Dieldrin (see Aldrin and Dieldrin)								
Dimethoate	0	0	assumed	0	assumed	0	assumed	0.2
Dinoseb	0	0	assumed	0	assumed	0	assumed	0.2
Diquat	0	0	assumed	0	assumed	0	assumed	0.2
Diuron	0	0	assumed	0	assumed	0	assumed	0.2
Endosulfan	0	0	assumed	0	assumed	0	assumed	0.2
Endrin	0	0	assumed	0	assumed	0	assumed	0.2
Glyphosate	0	0	assumed	0	assumed	0	assumed	0.2
Heptachlor epoxide	0	0	assumed	0	assumed	0	assumed	0.2
Lindane	0	0	assumed	0	assumed	0	assumed	0.2
Linuron	0	0	assumed	0	assumed	0	assumed	0.2
Malathion	0	0	assumed	0	assumed	0	assumed	0.2
MCPA	0	0	assumed	0	assumed	0	assumed	0.2
Methoxychlor	0	0	assumed	0	assumed	0	assumed	0.2
Metolachlor	0	0	assumed	0	assumed	0	assumed	0.2
Metribuzin	0	0	assumed	0	assumed	0	assumed	0.2
Paraquat (as dichloride)	0	0	assumed	0	assumed	0	assumed	0.2

Table C-9. Human Background Exposure Parameters

	Toddler EDI mg/kg-d	Adult EDI mg/kg-d	Source	C_a mg/m^3	Source	BSC mg/kg	Source	SAF
Parathion	0	0	assumed	0	assumed	0	assumed	0.2
Phorate	0	0	assumed	0	assumed	0	assumed	0.2
Picloram	0	0	assumed	0	assumed	0	assumed	0.2
Simazine	0	0	assumed	0	assumed	0	assumed	0.2
Tebuthiuron	0	0	assumed	0	assumed	0	assumed	0.2
Terbufos	0	0	assumed	0	assumed	0	assumed	0.2
Toxaphene	0	0	assumed	0	assumed	0	assumed	0.2
Triallate	0	0	assumed	0	assumed	0	assumed	0.2
Trifluarin	0	0	assumed	0	assumed	0	assumed	0.2
Other Organics								
Aniline	0	0	assumed	0	assumed	0	assumed	0.2
Bis(2-ethyl-hexyl)phthalate	0.01892	0.0058	PSL	0.031	PSL	0	assumed	0.2
Bis(Chloro-methyl)ether	0	0	assumed	0	assumed	0	assumed	0.2
Dibutyl phthalate	0.005	0.0019	PSL	0.00285	PSL	0	assumed	0.2
Dichlorobenzidine	0	0	assumed	0	assumed	0	assumed	0.2
Diisopropanolamine	0	0	assumed	0	assumed	0	assumed	0.33
Ethylene glycol	0.0344	0.0167	PSL	0	PSL	0	assumed	0.33
Hexachlorobutadiene	0.00012	0.00003	PSL	0.00006	PSL	0	assumed	0.2
Methylmethacrylate	1.13E-07	0	PSL	2.44E-07	PSL	0	assumed	0.2
MTBE	0.00000067	0.0000005	PSL	0.0000015	PSL	0	assumed	0.2
Nonylphenol	na	na	-	na	-	0	assumed	na
Phenol	0	0	assumed	0	assumed	0	assumed	0.2
Sulfolane	0	0	assumed	0	assumed	0	assumed	0.33

Notes:

na = not available or not applicable

EDI = estimated daily intake

C_a = background indoor air concentration

SAF = soil allocation factor

PSL = Priority Substance List assessment under Canadian Environmental Protection Act (CEPA) for corresponding substance.

CCME (1999) refers to the Canadian Environmental Quality Guidelines (CEQG) and updates, including the scientific supporting documents that are summarized in the CEQG.

Table C-10. Petroleum Hydrocarbon Subfraction Distribution

Soil				
	TPH Sub-fraction (Proportion of Total Fraction Mass)			
Fraction	**Fraction 1**	**Fraction 2**	**Fraction 3**	**Fraction 4**
Aliphatics				
C6-C8	0.55			
C>8-C10	0.36			
C>10-C12		0.36		
C>12-C16		0.44		
C>16-C21			0.56	
C>21-C34			0.24	
C>34				0.8
Aromatics				
C>7-C8				
C>8-C10	0.09			
C>10-C12		0.09		
C>12-C16		0.11		
C>16-C21			0.14	
C>21-C34			0.06	
C>34				0.2
Sum of all subfractions	1	1	1	1

Notes:

Source: CCME (2008a)

Groundwater				
	TPH Sub-fraction (Proportion of Total Fraction Mass)			
	Fine Soil		**Coarse Soil**	
Fraction	**Fraction 1**	**Fraction 2**	**Fraction 1**	**Fraction 2**
Aliphatics				
C6-C8	0.5768		0.6047	
C>8-C10	0.0663		0.0632	
C>10-C12		0.0239		0.024
C>12-C16		0.0015		0.0015
Aromatics				
C>7-C8				
C>8-C10	0.3569		0.3321	
C>10-C12		0.6029		0.6034
C>12-C16		0.3718		0.3711
Sum of all subfractions	1	1	1	1

Notes:

Source: CCME (2008a)

Subfraction distribution in groundwater not required for F3 and F4 due to low aqueous solubility

These values were calculated from the soil subfraction distributions above based on equilibrium partitioning assumptions, see text.

Table C-11. Surface Water Quality Guidelines

	Drinking Water	Aquatic Life	Irrigation	Livestock Water	Wildlife Water	DTED [1]
	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/kg-bw/d)
General and Inorganic Parameters						
Aluminum		see note 3	5	5		
Ammonia		see note 3				
Chloride	250	230	100			
Cyanide	0.2	0.005				
Fluoride	1.5	0.12	1	1		
Nitrate	45					
Nitrate + Nitrite (as nitrogen)				100		
Nitrite (as nitrogen)	1.0	0.06		10		
Sodium	200					
Sulphate	500			1000		
Sulphide (as H_2S)	0.05	0.002				
Total Dissolved Solids (TDS)	500		500	3000		
Metals						
Antimony	0.006					
Arsenic (inorganic)	0.01	0.005	0.1	0.025		
Barium	1					
Boron	5		0.5	5		
Cadmium	0.005	see note 3	0.0051	0.08		
Chromium (total)	0.05	see note 3	0.0049	0.05		
Copper	1	see note 3	0.2	0.5		
Iron	0.3	0.3	5			
Lead	0.01	see note 3	0.2	0.1		
Manganese	0.05		0.2			
Mercury	0.001	see note 3		0.003		
Nickel		see note 3	0.2	1		
Selenium	0.01	0.001	0.02	0.05		
Silver		see note 3	0.02	0.05		
Uranium	0.02		0.01	0.2		
Zinc	5	0.03	1	50		
Hydrocarbons						
Benzene	0.005	0.37		0.088	0.076	0.08
Toluene	0.024	0.002		4.91	4.25	4.46
Ethylbenzene	0.0024	0.09		3.20	2.77	2.91

Table C-11. Surface Water Quality Guidelines

	Drinking Water	Aquatic Life	Irrigation	Livestock Water	Wildlife Water	DTED [1]
	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/kg-bw/d)
Xylenes	0.3	0.18		13.1	11.3	11.9
Styrene	2.828	0.072				
Aliphatic C_6-C_8	136.85815	0.0465		53.6	46.4	48.72
Aliphatic $C_{>8}$-C_{10}	2.46675	0.0076		53.6	46.4	48.72
Aromatic $C_{>8}$-C_{10}	0.84205	0.14		53.6	46.4	48.72
F1				53.6	46.4	48.72
Aliphatic $C_{>10}$-C_{12}	2.75	0.00118		49.2	42.6	44.73
Aliphatic $C_{>12}$-C_{16}	2.75	0.000074		49.2	42.6	44.73
Aromatic $C_{>10}$-C_{12}	1.1	0.096		49.2	42.6	44.73
Aromatic $C_{>12}$-C_{16}	1.1	0.0554		49.2	42.6	44.73
F2				49.2	42.6	44.73
F3				79.7	69.0	72.45
F4				42.0	36.4	38.22
Acenapthene	1.414	0.0058		NGR	NGR	70
Acenaphthylene[2]		0.046				
Anthracene	7.07	0.000012		NGR	NGR	200
Fluoranthene	0.942666667	0.00004		NGR	NGR	50
Fluorene	0.942666667	0.003		NGR	NGR	50
Naphthalene	0.471333333	0.0011		NGR	NGR	28.6
Phenanthrene		0.0004		NGR	NGR	140
Pyrene	0.707	0.000025		NGR	NGR	25
Benz[a]anthracene		0.000018		NGR	NGR	20
Benzo[b+j]fluoranthene[2]		0.00048		NGR	NGR	20
Benzo[k]fluoranthene[2]		0.00048		NGR	NGR	20
Benzo[g,h,i]perylene[2]		0.00017				
Benzo[a]pyrene	0.00001	0.000015		NGR	NGR	2
Chrysene[2]		0.0014		NGR	NGR	20
Dibenz[a,h]anthracene[2]		0.00026				
Indeno[1,2,3-c,d]pyrene[2]		0.00021				
Halogenated Aliphatics						
Vinyl chloride	0.002					
1,1-Dichloroethene	0.014					
Trichloroethene (Trichloroethylene, TCE)	0.005	0.021		0.05		
Tetrachloroethene (Tetrachloroethylene,	0.03	0.111				

Table C-11. Surface Water Quality Guidelines

	Drinking Water (mg/L)	Aquatic Life (mg/L)	Irrigation (mg/L)	Livestock Water (mg/L)	Wildlife Water (mg/L)	DTED [1] (mg/kg-bw/d)
Perchloroethylene, PCE)						
1,2-Dichloroethane	0.005	0.1		0.005		
Dichloromethane (Methylene chloride)	0.05	0.0981		0.05		
Trichloromethane (Chloroform)	0.093	0.0018		0.1		
Tetrachloromethane (Carbon tetrachloride)	0.005	0.0133		0.005		
Tribromomethane				0.1		
Dibromochloromethane	0.188533333			0.1		
Chlorinated Aromatics						
Chlorobenzene	0.03	0.0013				
1,2-Dichlorobenzene	0.003	0.0007				
1,3-Dichlorobenzene		0.15				
1,4-Dichlorobenzene	0.001	0.026				
1,2,3-Trichlorobenzene	0.014	0.008				
1,2,4-Trichlorobenzene	0.015	0.024				
1,3,5-Trichlorobenzene	0.014					
1,2,3,4-Tetrachlorobenzene	0.032	0.0018				
1,2,3,5-Tetrachlorobenzene	0.0038					
1,2,4,5-Tetrachlorobenzene	0.0020					
Pentachlorobenzene	0.0094	0.006				
Hexachlorobenzene	0.000568			0.00052		
2,4-Dichlorophenol	0.0003	0.0002				
2,4,6-Trichlorophenol	0.002	0.018				
2,3,4,6-Tetrachlorophenol	0.001	0.001				
Pentachlorophenol	0.03	0.0005				
Dioxins and Furans	1.17833E-07					
PCBs	0.009426667					
Pesticides						
Aldicarb	0.009	0.001	0.0549	0.011		
Aldrin	0.0007	0.003				
Atrazine and metabolites	0.005	0.0018	0.01	0.005		
Azinphos-methyl	0.02	0.00001				
Bendiocarb	0.04					

Table C-11. Surface Water Quality Guidelines

	Drinking Water	Aquatic Life	Irrigation	Livestock Water	Wildlife Water	DTED [1]
	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/kg-bw/d)
Bromoxynil	0.005	0.005	0.00033	0.011		
Carbaryl	0.09	0.0002		1.1		
Carbofuran	0.09	0.0018		0.045		
Chlorothalonil	0.1414	0.00018	0.0058	0.17		
Chlorpyrifos	0.09	0.0000035		0.024		
Cyanazine	0.01	0.002	0.0005	0.01		
2,4-D	0.1	0.004		0.1		
DDT	0.09333	0.000001				
Diazinon	0.02					
Dicamba	0.12	0.01	0.000006	0.122		
Dichlofop-methyl	0.009	0.0061	0.00018	0.009		
Dieldrin	0.0007	0.000056				
Dimethoate	0.02	0.0062		0.003		
Dinoseb	0.01	0.00005	0.016	0.15		
Diquat	0.07					
Diuron	0.15					
Endosulfan	0.05656	0.00002				
Endrin	0.002828	0.000036				
Glyphosate	0.28	0.065		0.28		
Heptachlor epoxide	5.17949E-05	0.0000038				
Lindane	0.002828	0.00001		0.004		
Linuron	0.018853333	0.007	0.000071			
Malathion	0.19	0.0001				
MCPA	0.004713333	0.0026	0.000025	0.025		
Methoxychlor	0.9	0.00003				
Metolachlor	0.05	0.0078	0.028	0.05		
Metribuzin	0.08	0.001	0.0005	0.08		
Paraquat (as dichloride)	0.01					
Parathion	0.05	0.000013				
Phorate	0.002					
Picloram	0.19	0.029		0.19		
Simazine	0.01	0.01	0.0005	0.01		
Tebuthiuron	0.659866667	0.0016	0.00027	0.13		
Terbufos	0.001					

Table C-11. Surface Water Quality Guidelines

	Drinking Water	Aquatic Life	Irrigation	Livestock Water	Wildlife Water	DTED [1]
	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/kg-bw/d)
Toxaphene	0.000428485	0.0000002				
Triallate	0.122546667	0.00024		0.23		
Trifluarin	0.045	0.0002		0.045		
Other Organics						
Aniline	0.065986667	0.0022				
Bis(2-ethyl-hexyl)phthalate	0.41	0.016				
Bis(Chloro-methyl)ether	2.14242E-06					
Dibutyl phthalate	0.59	0.019				
Dichlorobenzidine	0.006972387					
Diisopropanolamine	3.6	1.6	2			
Ethylene glycol	31.42222222	192				
Hexachlorobutadiene	0.006042735	0.0013				
Methylmethacrylate	0.47					
MTBE	0.015	10				
Nitriloacetic acid	0.4					
Nonylphenol		0.001				
Phenol	0.5656	0.004		0.002		
Sulfolane	0.09	50	0.5			
Trihalomethanes - total (THMs)	0.1					

Notes:
See text for guideline sources
1. DTED = daily threshold effect dose from CCME (1999, 2008a). Included where used to calculate livestock and wildlife watering guidelines according to:

$$WQG = \frac{DTED x BW}{WIR}$$

Where:

WQG = water quality guideline (mg/L)
DTED = daily threshold effect dose (mg/kg-bw/d)
BW = body weight (kg)
WIR = water ingestion rate (L/d)

2. Aquatic life guideline from CCME (2008b)
3. See Surface Water Quality Guidelines for Use in Alberta (AENV, 1999)
NGR - no guideline required, calculated value > solubility